***United States Court of Appeals***

***for the Second Circuit***

# JOINT APPENDIX

ORIGINAL

# 76-7134

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P/S

# United States Court of Appeals

**For the Second Circuit.**

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U. S. PHILIPS CORP.,
*Plaintiff-Appellee,*

*v.*

NATIONAL MICRONETICS INC., *et al.*,
*Defendants-Appellants,*

*v.*

NORTH AMERICAN PHILIPS CORPORATION, and
N. V. PHILIPS GLOEILAMPENFABRIEKEN,
*Counter-Defendants.*

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## JOINT APPENDIX.

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UNITED STATES COURT OF APPEALS
FILED
AUG 2 1976
A. DANIEL FUSARO, CLERK
SECOND CIRCUIT

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UNITED STATES COURT OF APPEALS,

FOR THE SECOND CIRCUIT.

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U. S. PHILIPS CORP.,

*Plaintiff-Appellee,*

*-against-*

NATIONAL MICRONETICS INC., *et al.*,

*Defendants-Appellants,*

*-against-*

NORTH AMERICAN PHILIPS CORPORATION and N. V. PHILIPS GLOEILAMPENFABRIEKEN,

*Counter-Defendants.*

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -X

DOCKET ENTRIES.

| Date | Proceedings |
|---|---|
| 1971 | |
| Mar. 2 | Complaint Filed Issued Summons. |
| Mar. 16 | Filed Summons with Marshals Ret. Served Micronetics, Inc. and N.W. Buoymaster by N.W. Buoymaster on 3-11-71 (2) |
| Mar. 22 | Filed Plaintiff's Interrogatories to Defendants. |
| Mar. 26 | Filed stipulation and order extending defts. Micronetics, Inc. and N.W. Buoymaster's time to answer complaint to 30 days, namely 4/30/71. So ordered. Cannella, J. |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1971 | |
| Apr. 15 | Filed Defendants' First Set of Interrogatories to Plaintiff. |
| Apr. 20 | Filed Defendants' Answers to Plaintiff's Interrogatories. |
| May 3 | Filed ANSWER to the complaint. |
| May 18 | Filed pltff's Reply to counterclaims. |
| May 18 | Filed pltff's Answers to defts first set of interrogs. |
| Jul. 9 | Filed defts' notice to take deposition of pltff. on 8-24-71 |
| Aug. 12 | Filed Response to Request for Production of Documents. |
| 1972 | |
| Mar. 24 | Filed Notice of Motion re: Add Parties. Ret. 4/18/72. (for defendants). |
| Mar. 24 | Filed Memorandum in support of defendants' motion to join additional parties. |
| Apr. 13 | Filed Notice of Motion re: Separate Trial. Ret. 4/25/72. (by plaintiff). |
| Apr. 13 | Filed Memorandum in support of motion under Rule 42(b). |
| Apr. 17 | Filed stip to adj. deft's motion ret. 4-18-72 to 4-25-72. |
| Apr. 21 | Filed affidavit of R.G. Pelton in opposition to deft's motion ret, 4-25-72. |
| Apr. 21 | Filed pltff's memorandum in opposition to deft's motion ret. 4-25-72. |
| Jun. 16 | Filed defts' Supplemental answers to pltff's interrogs. |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1972 | |
| Sep. 28 | Filed Memo End. on Motion paper dated 3/24/72. The motion by dfts. for leave to serve an amended answer joining North American Philips Corp. & N.V. Philips Gloeilampenfabrieken as parties dft. on the counterclaims is granted, etc. So Ordered McLean J. |
| Sep. 28 | Filed Memo. End. on motion dated 4/13/72. Motion is granted as Indicated. McLean J. |
| Nov. 1 | Filed Affidavit of Stephen B. Judlowe in support of issuance of a 30-day summons. |
| Nov. 10 | Filed summons with marshal's ret. Served North American Philips Corp. by Joseph C. Miranda, Asst. Sec. on 11/3/72. |
| Nov. 24 | Filed Reply of U.S. Philips Corp to counterclaims. |
| Dec. 8 | Filed stipulation and order extending defendants time to answer counterclaim to 12/15/72. So ordered. Ryan, J. |
| Dec. 11 | Filed Pltffs affdvt & notice of motion for an order implementing decision on motion for severance & stay. Ret: 12-14-72. |
| Dec. 14 | Filed Stip & Order under Rule 7(b) F.R.C.P. for order implementing decision on motion for severance & stay. So Ordered 12-14-72 is adjourned to 12-28-72. RYAN, J. |
| Dec. 19 | Filed Deft North American Philips Corp reply. |
| Dec. 15 | Filed Stip & Order that the deft N.V. Philips Gloeilampenfabrieken to answer or move or make motion with respect to the 1st amended answer is extended from 12-21-72 to 1-22-73. So Ordered. RYAN, J. |
| 1973 | |
| Jan. 9 | Filed Defts Reply memorandum in opposition to pltffs motion to stay. |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1973 | |
| Jan. 9 | Filed Counter Defts North American Philips Corp Memorandum. |
| Jan. 18 | Filed Defts'. First Set of Interrogs. to North American Philips Corp. and N.V. Philips Gloeilampenfabrieken. |
| Jan. 23 | Filed Notice of Motion Ret. before Ryan, J. on 2/1/73 at 10 AM. re: dismiss counterclaim asserted against 3rd pty. deft. N.V. Philips Gloeilamp. |
| Jan. 23 | Filed third party deft's. Memorandum in support of its motion to dismiss. |
| Jan. 30 | Filed stipulation and order adjourning motion now ret. 2/1/73 to 2/8/73. So ordered. Ryan, J. |
| Jan. 31 | Filed stipulation and order adjourning motion now ret. 2/1/73 to 2/8/73. So ordered. Ryan, J. (by Sandoe, Hopgood & Calimaide). |
| Feb. 5 | Filed Defendants' First Set of Interrogs. to North American Philips Corp., N.V. Philips Gloeilampenfabrieken, et ano |
| Feb. 5 | Filed Defts'. Memorandum in opposition to 3rd pty. deft's. motion to dismiss. |
| Feb. 6 | Filed Notice of Deposition of Lionel Bishop, Robert Hess, Ralph Casper and John P. Moon. |
| Feb. 21 | Filed Response to Defendants' Interrogatories, First Set. |
| Feb. 22 | Filed Responses of counter-deft. North American Philips Corp. to defts'. First Set of Interrogatories. |
| Mar. 7 | Filed Notice of Motion Ret. 3/29/73 at 10 AM before Ryan, J. re: enlarge time to answer Interrogs. |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1973 | |
| Mar. 7 | Filed Objections of U.S. Philips Corp. to Deft's. First Set of Interrogs. |
| Mar. 8 | Filed response to defts' interrogatories on jurisdictional issues. |
| Mar. 13 | Filed notice of motion, ret. Mar. 29, 73 at 10:00 a.m. Re: compel further answers to interrogatories. |
| Mar. 13 | Filed pltf. ,e,o in support of motion. |
| Mar. 13 | Filed Objections of North American Philips Cor to deft's first set of interrogs. on jurisdictional issued. |
| Mar. 19 | Filed Stip and Order Deposition of Lionel Bishop withdrawn; depositions of Robert Hess, Ralph Casper and John P. Moon postponed until Mar. 26, 73. So Ordered. RYAN, J. |
| Mar. 22 | Filed Defendants' Response to Pltf's. Requests for Production pur. to Rule 34. |
| Apr. 2 | Filed Response of Pltff. to Dft's Motion to compel Answers to Interrogs. |
| Apr. 11 | Filed Pltff's 2nd Set of Interrogs. to Dfts. & request to produce. |
| May 10 | Filed Notice of Joinder in Motion of North American Philips Corp. counter-defendant. |
| May 10 | Filed Stip & Order that the time for pltffs. to answer to dfts. interrogs. is extended to 5/21/73. Ryan J. |
| May 29 | Filed Dfts. response to pltffs. second interrogs. & request for production. |
| Jun. 5 | Filed Dfts. First request to pltff. U.S. Philips & Dft. on the counterclaims N.V. Philips for production pursuant to FRCP rule 34. |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1973 | |
| Jun. 7 | Filed Dfts. Further response to pltffs. second Interrogs. & request for production. |
| Jun. 25 | Filed Supplemental Answers by Counter Dft. North American Philips Corp. to dfts. First Set of Interrogs. |
| Jun. 28 | Filed Request for admissions by dft. |
| July 9 | Filed Pltffs. response by U.S. Philips to dfts. First request for production. |
| Jul. 25 | Filed Pltffs. Notice of Deposition of Innotech, Inc. on 8/7/73. |
| Jul. 25 | Filed Pltffs. Notice of Deposition of Emhart Corp., Glass Testing Laboratories, of Hartford Conn. on 8/16/73. |
| Sep. 17 | Filed Supplemental Answers to Deft's First Set of Interrogs. |
| Nov. 9 | Filed Defts. further request of N.V. Philips for production pursuant to rule 34. |
| Nov. 19 | Pre-Trial conf. held. |
| Nov. 26 | Filed Order that this matter is referred to Magistrate Schreiber for further Pretrial hearings. Ryan J. (mailed notice) |
| Dec. 17 | Filed Response to request for production of documents. by 3rd pty deft. N.V. Philips Gloeilampenfabrieken. |
| Dec. 17 | Filed 3rd pty deft. N.V. Philips Gloeilampenfabrieken Answer to interrogs. |
| Dec. 26 | Filed response to request for production of documents. |
| Dec. 26 | Filed Stip & Order that the time for 3rd pty deft. N.V. Philips to answer to defts. requests for production is extended to 12/21/73. Ryan J. |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1973 | |
| Mar. 27 | PRE-TRIAL CONFERENCE HELD BY RYAN, J. |
| Nov. 21 | PRE-TRIAL CONFERENCE HELD BY SCHREIBER, J. |
| 1974 | |
| Jan. 25 | Filed 3rd pty deft's (N.V. Philips) answers to interrogs. |
| Feb. 5 | Filed defts' request for production & interrog. of 2-4-74. |
| Feb. 25 | Filed Pltffs. Notice of taking deposition of H.J. Newton, et al beginning 3/26/74. |
| Mar. 11 | Filed Pltffs. 3rd set of Interrogs to defts. request to produce. |
| Mar. 11 | Filed Responses of counter deft. North American Philips Corp., to Defts. request for production & interrog. of 2/4/74. |
| Feb. 1 | Pre trial conf held by Mac Schreiber |
| Mar. 14 | Pre trial conf held by Schreiber |
| Apr. 17 | Filed 3rd pty deft. N.V. Philips, etc. Response to request for production of documents. |
| May 23 | Filed North American Philips Response to Defts. request for Admissions. |
| May 23 | Filed North American Philips Response to Defts. Interrog. of 3/20/74. |
| May 23 | Filed Pltffs. Answers to defts. Interrogs. of 4/3/74. |
| May 23 | Filed Pltffs. Response to defts. request for admissions. |
| May 23 | Filed Pltffs. Response to defts. Interrog. 3/20/74. |
| May 24 | Filed order on change of name of deft.--Ryan, J. |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1974 | |
| May 30 | Filed Defts. response to pltffs. 3rd set of Interrogs. |
| Jul. 25 | Filed 3rd pty defts. N.V. Philips Gloeilampen-fabrieken Recommendation & Order by Magistrate Schreiber. So Order Ryan J. (mailed notice) |
| Jul. 29 | Filed Defts. Notice of Deposition of North American on 8/20/74. |
| Jul. 29 | Filed Defts Notice of Deposition of Innotech Inc. on 8/27/74. |
| Aug. 13 | Mailed notice of reassignment. |
| Sep. 11 | Filed Stip & Order on Confidential Documents. as indicated. Owen J. |
| Sep. 13 | Filed Defts'. further interrogs. and request for production of September 1974 to U.S. Philips and N.V. Philips. |
| Sep. 20 | Filed Counter-deft. No. American Philips Corp notice of entry of stip & order dtd. 9-11-74. |
| Sep. 16 | PRE-TRIAL CONFERENCE HELD BY SCHREIBER |
| Oct. 21 | Filed 3rd pty deft's (N.V. Philips) response to interrogs. & requests for production |
| Oct. 27 | PRE-TRIAL CONFERENCE HELD BY SCHREIBER |
| Nov. 1 | Filed Supplemental Answers to Defts. Further Interrogs. of 9/74. |
| Nov. 5 | PRE-TRIAL CONFERENCE HELD BY SCHREIBER |
| Nov. 12 | Filed deft Nat. Micronetics Inc. notice to take deposition of General Electric Co. on 11-22-74 |
| Dec. 4 | Filed affdvt of Patrick A. Rivelli, Vice President of Nat'l Micronetics, Inc. |
| Dec. 4 | Filed deft's responses to pltff's second request for admissions. |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1974 | |
| Dec. 4 | Filed defts' supplemental answers to interrogs. |
| Dec. 6 | Filed deposition of pltff. by Frank R. Trifari, Mailed notices. |
| Dec. 6 | Filed deposition of pltff. by Russell Pelton. Mailed notices. |
| Dec. 11 | Filed pltff's supplemental answers to interrogs. of Sep. 1974. |
| Dec. 11 | Filed pltff's supplemental answers to interrogs. of Apr. 3, 1974. |
| Dec. 13 | Filed deft's (Micronetics) notice of deposition. |
| Dec. 20 | Filed pltff's interrogs. |
| Dec. 31 | Filed defts' interrogs. |
| Dec. 31 | Filed defts' requests for admissions |
| 1975 | |
| Jan. 9 | Filed pltff's interrogs. of Nov. 1974. |
| Jan. 24 | Filed 3rd pty deft's (N.V. Philips) answers to interrogs. |
| Jan. 14 | PRE-TRIAL CONFERENCE HELD BY SCHREIBER |
| Jan. 27 | PRE-TRIAL CONFERENCE HELD BY SCHREIBER |
| Jan. 31 | Filed stip & order extending 3rd pty deft's (N.V. Philips) time to answer interrogs. & Requests for Admissions to 2-3-75--Owen, J. |
| Feb. 5 | Filed Pltffs. response to defts interrogs. of 12/74. |
| Feb. 5 | Filed Response by North American Philips Corp. to defts. requests for admission 12/74. |
| Feb. 5 | Filed Pltffs 3rd request for admission. |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1975 | |
| Feb. 5 | Filed further supplemental answers to defts further interrogs. of 4/3/74. |
| Feb. 5 | Filed Response by U.S. Philips Corp. to defts request for admission of 12/74. |
| Feb. 11 | Filed 3rd pty deft's (N.V. Philips) response to request for admissions. |
| Feb. 11 | Filed 3rd pty deft's (N.V. Philips) response to interrogs. |
| Feb. 18 | Filed pltff's request for admission. |
| Feb. 18 | Filed defts' response to interrogs. |
| Feb. 25 | Filed defts' notice of deposition with accompanying production requests. |
| Feb. 26 | Filed deft's response to interrogs. #17. |
| Feb. 26 | Filed defts' interrogs. |
| Feb. 28 | Filed defts' interrogs. & production request of 2-2-75. |
| Feb. 28 | Filed defts' further requests of pltff. for admissions. |
| Feb. 28 | Filed defts' interrogs. & production requests of 2-28-75. |
| Mar. 3 | Filed pltff's interrogs. of 2-26-75. |
| Mar. 4 | Filed pltff's requests for admissions of 2-28-75. |
| Feb. 25 | PRE-TRIAL CONFERENCE HELD BY SCHREIBER |
| Mar. 14 | PRE-TRIAL CONFERENCE HELD BY SCHREIBER |
| Mar. 19 | Mailed notice of reassignment. |
| Mar. 19 | Filed depcsition of Dr. Frederick G. Keihn, dated 12-30-74. (mailed notice) |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1975 | |
| Mar. 20 | Filed Deft's. notice of deposition of Allan McFadden on 3-27-75. |
| Mar. 20 | Filed 3rd pty deft's. (N.V. Philips) answers to defts'. interrogs. |
| Mar. 24 | Filed Deft's. responses to Pltff's. requests for admissions 47-77. |
| Apr. 1 | Filed Defts'. designation of prior art. |
| Apr. 2 | Filed Pltff's. request for production of documents to Deft. National Micronetics, Inc. on 4-25-75. |
| Apr. 3 | Filed Pltff's. response to Deft's. further requests for admissions. |
| Apr. 7 | Filed Deft's. response to Pltff's. requests for admissions 43-46. |
| Apr. 7 | Filed Deft's. response to Pltff's. requests for admissions 78-112. |
| Apr. 4 | PRE-TRIAL CONFERENCE HELD BY WARD |
| Apr. 4 | Filed ORDER that all discovery be completed by 4-25-75, that counsel confer regarding a pre-trial order by 4-30-75 and that a pre-trial order be filed by 5-15-75.....Ward, J. (mailed notice) |
| Apr. 1 | PRE-TRIAL CONFERENCE HELD BY SCHREIBER |
| Apr. 4 | PRE-TRIAL CONFERENCE HLED BY SCHREIBER |
| Apr. 8 | Filed Pltff's. response to Defts'. interrogs. & production requests of 2-25-75. |
| Apr. 8 | Filed Pltff's. response to Defts'. interrogs. & production requests of 2-28-75. |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1975 | |
| Apr. 18 | Filed Stip. & Order with regard to treatment of confidential materials to be submitted to Micronetics by U.S. Philips & N.V. Philips..... Ward, J. |
| May 9 | Filed Pltff's. supplemental response to Defts'. interrogs. of December 1974. |
| May 9 | Filed Pltff's. supplemental response to Defts'. requests for admission of December 1974. |
| Jun. 2 | Filed Consented Pre-trial Order.....Ward, J. |
| Jun. 4 | Filed 3rd Pty Deft's. (N.V. Philips) response to Deft's. interrogs. & production requests. |
| Jun. 11 | Filed Stip & Order regarding Agreement dated 6-1-69 between International Business Machines Corporation and N.V. Philips' Gloeilampenfabrieken .....Ward, J. |
| Jun. 10 | Before Ward, J. trial begun. |
| Jun. 11 | Trial continued. |
| Jun. 12 | Trial continued. |
| Jun. 16 | Trial continued. |
| Jun. 17 | Trial continued. |
| Jun. 18 | Trial continued. |
| Jun. 19 | Trial continued and concluded. Decision reserved. |
| Jul. 14 | Filed Transcript of record of proceedings, dated 6-17-75 |
| Jul. 23 | Filed Transcript of record of proceedings, dated June 10, 11, 12, 16, 17, 1975 |
| Jul. 23 | Filed Transcript of record of proceedings, dated Jne 18-19-20, 1975 |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1975 | |
| Jul. 29 | Filed Defts. Proposed Findings of Fact. |
| Sep. 2 | Filed Recommendation & Order by Magistrate Schreiber - Unsigned by the Judge. |
| 1976 | |
| Jan. 27 | Fld Opinion #43786...Conclusions: In sum, pltff. is entitled to judgm declaring Peloschek paten claims 1,2,3,4,6,8,9,10, & 11 valid and infringed, and claims 5,14, & 15 valid but not infringed. Additionally, pltff. is entitled to a perm. inj prohibiting infringement of the Peloschek patent. Defts are entitled to a judgment declaring the Duinker patent invalid. The stay of the counterclaims is vacated and the ptys are directed to proceed to the adjudictions of the counterclaims and the issue of damages... The foregoing constitutes the findings of fact and conclusions of law of the Court for the purposes of Rule 52FRCP. Settle judg. on notice ....Ward, J. mn |
| Feb. 11 | Fld Defts' Memo on the iss of fees and expenses. |
| Feb. 11 | Fld Pltff's Memo in reply to deft's brief on the stay and Discovery. |
| Feb. 11 | Fld Pltff's Memo in reply to defts' opposition to pltff's motion of stay. |
| Feb. 11 | Fld Defts' memo in opposition to pltff's motion for order of stay etc. |
| Feb. 11 | Fld Defts' brief on the stay & Discovery. |
| Feb. 11 | Fld Further Memo of Defts Micronetics etc to dismiss. |
| Feb. 11 | Fld Defts' Memo in opposition to pltff's rule 37 Motion. |
| Feb. 11 | Fld Index of Exhits annexed to defts' memo in opposition to pltff's stay motion. |

DOCKET ENTRIES

| Date | Proceedings |
|---|---|
| 1976 | |
| Feb. 11 | Fld Defts' Notice of Motion ret 4-5-73. |
| Feb. 11 | Fld Defts' Notice of Motion ret 9-17-73. |
| Feb. 11 | Fld Pltff's Proposed Findings of Fact and Conclusions of Law. |
| Feb. 11 | Fld Order issues raised by the counterclaims are severed...etc....Ryan, J. |
| Feb. 11 | Fld Defts' Pretrial Memo. |
| Feb. 11 | Fld Stip on Confidental Documents. |
| Feb. 11 | Fld Trial Brief. |
| Feb. 18 | Fld Pltff's Memo in opposition to defts' form of Judgment. |
| Feb. 18 | Fld Attachments to pltff's memo in opposition to defts' form of judg. |
| Feb. 20 | Fld Defts' Reply Memo in support of their form of judgment. |
| Feb. 25 | Fld Memo in support of defts' form of judgment. |
| Feb. 25 | Fld Exhibits in support of Entry of their form of Judgment. |
| Feb. 25 | Fld Judgment....Ordered that: Pltff is the Owner of U.S. Letters Patent #3,246,383, iss'd on 4-19-66, in the names of H.P. Peloschek and M.H.M. Vrolijks; and of U.S. Letters Patent #3,024,318, iss'd 3-6-62, in the names of S. Duinker and J. Bos, and of the right to recover for infringement thereof...Said Duinker et al Patent #3,024,318 is invalid and the complt is dismissed as to it.....etc....Deft N. W. Buoymaster did not infringe or induce infringement of either of pltff's said patents, and the complt is dismissed as to him...The stay heretofore Ordered as to defts' counterclaims is vacated and the parties are directed to proceed to an adjudication of |

DOCKET ENTRIES

| Dat | Proceedings |
|---|---|
| 1976 | |
| | the counterclaims.....There having been a split decision on the adjudication of the patent issues, no costs are awarded to either pty...Para 1-5 herein above constitute a final judgment of this Court pur to Rule 54(b) FRCP as to the patent issues. The Court hereby expressly determines that there is no just reason for delay and expressly directs the entry of judgment.... Ward, J. mn Judgment Entered 2-25-76-Clerk ent 2-26-76. |
| Mar. 17 | Fld Defts' Notice of Appeal to USCA from Order of 2-25-76. copies of notice mailed on 3-18-76 to Sullivan & Cromwell----Darby & Darby. |

COMPLAINT.

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

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U. S. PHILIPS CORPORATION, :

Plaintiff, :

v. : Civil Action No. 71C 921

MICRONETICS, INC., and N. W. BUOYMASTER, :

Defendants. :

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COMPLAINT

1. This is an action arising under the Patent Laws of the United States, Title 35, U. S. Code; and this Court has jurisdiction over the present action, under 28 U.S.C. 1338(a), inter alia. Venue is proper within this Judicial District, under 28 U.S.C. 1400(b), inter alia.

2. Plaintiff U. S. Philips Corporation (hereinbelow sometimes referred to as "USPC") is a corporation created under and by virtue of the laws of the State of Delaware with its sole principal place of business in the State of New York.

3A. On information and belief, defendant Micronetics, Inc. (hereinbelow sometimes referred to as "MICRONETICS") is a corporation created under and by

virtue of the laws of the State of New York, with a regular and established place of business, including a manufacturing plant, at Kingston, New York, within this Judicial District where it has performed the acts complained of herein.

B. On information and belief, defendant BUOYMASTER is and at all relevant times has been an officer, director and shareholder of defendant MICRONETICS, and directs, guides, manages and controls MICRONETICS, and has both personally and as an officer of MICRONETICS caused the acts herein complained of to be done.

4A. On March 6, 1962, United States Patent No. 3,024,318 (hereinafter "318") was duly and legally issued for an invention in a "Glass Gap Spacer For Magnetic Heads".

B. On August 25, 1964, United States Patent No. 3,145,453 (hereinafter "453") was duly and legally issued for an invention in a "Method of Producing Magnetic Heads with Bonding Glass Gap Spacers".

C. On April 19, 1966, United States Patent No. 3,246,383 (hereinafter "383") was duly and legally issued for an invention in a "Method of Manufacturing Magnetic Heads with Bonding Gap-Filling Materials".

D. Plaintiff USPC is the sole owner of each of said 318, 453 and 383 patents with the right to recover for all past infringement thereof.

5. On information and belief,

(a) on numerous occasions during the last six years and subsequent to the respective dates of grant of said 318, 453 and 383 patents defendants have infringed said patents by making, using and selling the patented devices of the 318 patent and by actively inducing others to use and/or sell said devices, and by carrying out or using the patented processes of the 453 and 383 patents, which acts were performed in this Judicial District, and possibly elsewhere, without license from plaintiff;

(b) the foregoing infringing acts were of a willful and wanton nature, because at the time they were committed defendants were aware of plaintiff's aforesaid patents, and knew that their activities would and did infringe said patents and damage plaintiff's business and rights in the patented inventions, but nevertheless, defendants proceeded with their infringing activities in disregard of plaintiff's patents and rights.

6. Plaintiff has given defendants notice of its aforesaid infringement and has offered to grant a license under said patents, but defendants have refused

to terminate its infringement thereof or to accept license thereunder.

7. Plaintiff has been substantially damaged by defendants' aforementioned acts, and said damages are of a continuing and proliferating nature and will further damage plaintiff unless enjoined.

WHEREFORE, plaintiff prays for:

A. A preliminary and final injunction against further infringement of United States Patents Nos. 3,024,318; 3,145,453, and 3,246,383 by defendants and those controlled by or in privity with defendant.

B. An accounting to determine the extent of defendants' infringing activities and the damages caused plaintiff by said activities.

C. Damages adequate to compensate plaintiff for defendants' infringement of said patent, to be trebled because of the willful and wanton nature of defendants' infringing activities.

D. Reasonable attorneys' fees, the costs of this action, and such other and further relief as to the Court may seem just and the circumstances warrant.

DARBY & DARBY

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OF COUNSEL:
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FIRST AMENDED ANSWER.

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

----------x

U.S. PHILIPS CORPORATION,
Plaintiff,

-against-

MICRONETICS, INC. and N.W. BUOYMASTER,
Defendants,

-against-

CIVIL ACTION
No. 71-921

NORTH AMERICAN PHILIPS CORPORATION and
N.V. PHILIPS GLOEILAMPENFABRIEKEN,
Defendants on the Counterclaims.

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FIRST AMENDED ANSWER

Defendants answering the complaint allege as follows:

1. Paragraph one of the complaint is admitted.

2. Defendants have no knowledge of the allegations contained in paragraph two of the complaint.

3(a) Paragraph 3(a) is admitted.

3(b) Defendants admit that Buoymaster is an officer, director and shareholder of defendant, Micronetics, but deny the remaining allegations contained in paragraph 3(b).

4(a) Defendants admit that Patent No. 3,024,318 issues on March 6, 1962 but deny that the patent was duly or legally issued for an invention.

FIRST AMENDED ANSWER

4(b) Defendants admit that Patent No. 3,145,453 issued on August 25, 1964 but deny that the patent was duly or legally issued for an invention.

4(c) Defendants admit that Patent No. 3,246,383 issued on April 19, 1966 but deny that the patent was duly or legally issued for an invention.

4(d) Defendants admit the allegation contained in paragraph 4(d).

5(a)(b) Defendants deny each and every allegation contained in paragraphs 5(a) and 5(b) of the complaint.

6. Defendant Micronetics admits that it received notice of alleged infringement, and it further admits that an exorbitant, impractical and economically unacceptable license was offered to it for a royalty of 15% on sales. Defendant Micronetics refused to accept such license because its products do not infringe the aforesaid patents, and, moreover, the patents are invalid as more particularly explained in the following affirmative defenses.

7. Defendants deny each and every allegation contained in paragraph 7 of the complaint.

## FIRST AMENDED ANSWER

FURTHER ANSWERING THE COMPLAINT, DEFENDANTS ALLEGE THE FOLLOWING AFFIRMATIVE DEFENSES:

8. The aforesaid patents are invalid for any one or more of the reasons specified in 35 U.S.C. 102, and more particularly because,

(a) The alleged inventions were known or used by others in this country, or patented or described in a printed publication in this or a foreign country before the alleged inventions thereof by the applicants for the aforesaid patents;

(b) the alleged inventions were patented or described in printed publications in this or in foreign countries or in public use or on sale in this country, more than one year prior to the respective dates of the applications for the patents;

(c) the alleged inventions were described in patents granted on applications for patents by another filed in the United States before the alleged inventions thereof by applicants for the aforesaid patents.

FIRST AMENDED ANSWER

9. Each of the aforesaid patents is invalid under 35 U.S.C. 103 as the differences between the patents and the prior art are such that the subject matter as a whole would have been obvious at the time each of the alleged inventions was made to a person having ordinary skill in the art to which the subject matter pertains.

10. Each of the patents is invalid for not complying with 35 U.S.C. 112 as the specifications do not contain written descriptions of the alleged inventions in such full, clear, concise and exact terms as to enable any person skilled in the art to make and use the same; further, each of the specifications do not set forth the best mode contemplated by the inventors for carrying out the respective alleged inventions. In addition, each of the specifications do not conclude with claims which particularly point out and distinctly claim the subject matter which the inventors regard as their inventions.

11. Each of the patents is not infringed because it recites an aggregation of elements, which aggregation is not utilized by defendants.

12. Each of the patents is not infringed because amendments and additions were made to the claims during the prosecution of the respective patent applications before the

United States Patent Office, and plaintiff is now estopped to construe the claims so as to recapture subject matter which was expressly or impliedly abandoned by the amendments and additions to the claims, and by representations made to the Patent Examiner.

FOR ITS FIRST COUNTERCLAIM
DEFENDANTS ALLEGE:

13. This counterclaim is based on Section 7 of the Clayton Act and/or Sections 1 and 2 of the Sherman Act.

14. Plaintiff is a corporation organized and existing under the laws of Delaware with its principal place of business in the Southern District of New York. North American Philips is a large publicly held, New York Stock Exchange listed Delaware corporation having its headquarters in New York in this District. N.V. Philips is a corporation of the Netherlands having its headquarters in Eindhoven, Netherlands, and which is doing business in this State and in this District. N.V. Philips is one of the world's large industrial concerns, and is a publicly held corporation.

15. Plaintiff is owned or controlled by or associated with the Hartford Bank and Trust Company of Hartford, Connecticut as trustee pursuant to a trust (herein deemed: the Philips Trust) the exact terms of which are presently not known to defendants.

On information and belief, the trust was established by N.V. Philips, and the trust beneficiaries are the N.V. Philips stockholders. As one attribute of the trust, U.S. Philips owns thousands of United States patents covering inventions made by N.V. Philips abroad, including the three patents in suit. The Hartford Bank and Trust Company as trustee also owns a controlling interest in North American Philips.

16. This Court has jurisdiction over the counterclaim pursuant to 28 U.S.C. 1337, and the doctrine of pendent jurisdiction. Venue in this District is proper with respect to U.S. Philips and North American Philips under 28 U.S.C. 1391. Venue here is properly founded regarding N.V. Philips pursuant to 28 U.S.C. 1391 and/or CPLR §§301, 302 and 313. The amount in controversy, exclusive of interests and costs, exceeds the sum of ten thousand dollars.

17. The combine of N.V. Philips, North American Philips, U.S. Philips, and the Philips Trust (herein: the Combine) is a world ranking industrial complex having total sales of several billions of dollars, owning or controlling many thousands of U.S. and foreign patents and owning or controlling a large number of companies throughout the world well in excess of 500. On information and belief, many of these companies in foreign countries are cartels, illegal combines and monopolies.

FIRST AMENDED ANSWER

18. Patent assets owned in whole or in part by the said large number of companies are acquired in the United States by plaintiff, either directly from said companies, or indirectly through the Philips Trust or the said N.V. Philips. As a result of the said acquisitions, plaintiff owns or controls in excess of 4,000 U.S. patents. The patents constitute a "pool" which is employed for the benefit of the Philips Trust, companies owned or controlled by the Trust, Combine companies, North American Philips, N.V. Philips, and beneficiaries of the Trust.

19. The patents in suit, Nos. 3,024,318; 3,145,453; and 3,246,383 form part of the aforesaid patent pool. Plaintiff uses and is attempting to use said patents in a manner which has and will continue to have the effect of lessening competition by offering to non-members of the pool and Combine, exorbitant and discriminatory licenses.

On information and belief, plaintiff has granted royalty-free license to at least one member of the pool, Ferroxcube Corporation, a subsidiary of North American Philips and a principal competitor of defendants, or has otherwise by express or tacit agreement refrained from seeking tribute from Ferroxcube with respect to the patents in suit. Correspondingly, plaintiff has offered defendant Micronetics a license at a 15% royalty.

FIRST AMENDED ANSWER

20. The offer of a 15% royalty was part of a plan to damage defendant Micronetics. Plaintiff and defendants to the counterclaims knew that such royalty was economically intolerable to defendant Micronetics, and would be rejected out of necessity. Plaintiff then brought this predatory action to annoy, embarrass, and harass Micronetics in the trade, and to discourage customers and prospective customers from purchasing the accused products from Micronetics and instead purchase competing products from Ferroxcube Corporation which received preferential treatment from the patent pool.

21. The aforesaid acts and agreements restrain trade or tend to lessen competition, and are in furtherance of attempts to monopolize commerce in computer grade ferrite magnetic recording heads.

FOR ITS SECOND COUNTERCLAIM
DEFENDANTS ALLEGE:

22. This counterclaim is based on patent misuse.

23. Defendants reallege and reassert each of the allegations contained in paragraphs 14-21 inclusively.

WHEREFORE, defendants pray that:

A. Each of the aforesaid Patents Nos. 3,024,318, 3,145,453 and 3,246,383 is invalid and not infringed;

FIRST AMENDED ANSWER

B. Each of the aforesaid patents is unenforceable because of patent misuse and/or antitrust violations;

C. The Court adjudge and decree that the aforementioned combinations and conspiracies resulting in the aggrandizements of patent assets in plaintiff are in violation of Sections 1 and 2 of the Sherman Act;

D. The Court adjudge and decree that the acquisition of patents, having the effect of lessening competition is in violation of Section 7 of the Clayton Act;

E. They be awarded damages, the exact amount to be determined in an accounting proceeding, which shall then be trebled as a result of the antitrust violations;

F. They be awarded attorneys fees and costs of the lawsuit, and such other and further relief as the nature of the case may require and the Court may deem just and proper in the premises.

MICRONETICS, INC. and
N.W. BUOYMASTER

John M. Calimafde

Dated: March 23, 1972

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FIRST AMENDED ANSWER

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OPINION.

Hon Robert Ward

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

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U. S. PHILIPS CORPORATION,

Plaintiff,

-against-

NATIONAL MICRONETICS INC., and NED W. BUOYMASTER,

Defendants,

-against-

NORTH AMERICAN PHILIPS CORPORATION, and N. V. PHILIPS GLOEILAMPENFABRIEKEN,

Counter-Defendants.

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OPINION

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A P P E A R A N C E S

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OPINION

WARD, J.

This is an action alleging infringement of U. S. Patent No. 3,024,318 to Duinker et al. for a "Glass Gap Spacer for Magnetic Heads" (hereinafter the "Duinker patent") and U. S. Patent No. 3,246,383 to Peloschek et al. for a "Method of Manufacturing Magnetic Heads with Bonding Gap - Filling Materials" (hereinafter the "Peloschek patent"). For the reasons hereinafter stated, the Court holds the Duinker patent invalid and the Peloschek patent valid and infringed.

I. The Parties, Jurisdiction and Venue

Plaintiff U.S. Philips Corporation (hereinafter "Philips") is a Delaware corporation with its principal place of business in New York City whose primary business is licensing patents. It owns the rights to the two patents in suit through assignment from N. V. Philips Gloeilampen-fabrieken (hereinafter "N. V. Philips"), whose employees developed the inventions which are the subject of the patents.

Defendant National Micronetics Inc. (hereinafter "Micronetics") is a New York corporation with its principal place of business at West Hurley, New York. It is in the business of manufacturing glass bonded ferrite cores for use in magnetic recording heads. Defendant Ned W. Buoymaster is one of the founders and President of Micronetics. He resides in Woodstock, New York.

This Court has jurisdiction of the parties and the

subject matter of this action and venue is properly laid in this district.

II. The Pleadings

The complaint filed on March 2, 1971 originally charged defendants with infringement of three patents owned by plaintiff. Prior to trial, plaintiff withdrew the infringement claim relating to one of these patents. As to the infringement of the two remaining patents, plaintiff seeks a declaratory judgment, an injunction and damages. The defendants, by their answer, deny infringement and challenge the validity of both patents on the grounds of obviousness and indefiniteness. In addition, defendants have counterclaimed against plaintiff and additional defendants on the counterclaim, N. V. Philips and North American Philips Corporation, for patent misuse and violation of the antitrust laws. The counterclaims were severed and stayed pending the outcome of the patent infringement action which was tried to the Court.

III. Background

Magnetic recording heads are devices used to record ("write") signals representing sound or information on a moving magnetic medium such as a tape, belt, or disc or to pick up ("read") such recorded signals. A magnetic recording

head consists of a nearly closed ring of magnetic material with a minute non-magnetic gap around which a ring coil of wire is wrapped. 2-10-76 R.W. The ring and gap structure comprise the core of the head which is the focus of this litigation. An electric current, when passed through the head, will create a small magnetized spot on the magnetic medium opposite the gap. This spot represents the recorded information. As the medium moves, successive, discrete spots will be magnetized. The smaller the spots and the closer they are spaced, the more information can be stored in the least amount of magnetic medium. This may be referred to as "high resolution" or " high bit density." The achievement of increasingly higher resolution or bit density depends to a great extent on various qualities of the recording head, including the size of the gap and the material of which the head is made. The shorter the gap, the smaller the magnetized spot. Ideally, the head material has low electrical conductivity to minimize the losses; that is, the least amount of electrical current introduced into the head will be lost to the generation of heat.

Magnetic recording is an old art but did not become commercially significant until World War II. Although the device has many applications, the principal use of concern in this litigation has been in computers.

OPINION

IV. The Duinker Patent

The Duinker patent, issued March 6, 1962 on an application filed September 11, 1956, concerns a magnetic recording head having a core formed of sintered ferromagnetic oxide material, or ferrite,[1] with a glass filled gap. The patent addresses itself to the problem of chipping of the gap edges in heads composed of ferrite. It teaches that if the coefficients of expansion (hereinafter "CTE's")[2] of the glass and ferrite are matched to a degree closer than that necessary merely to assure a good bond, chipping of the ferrite edges in use will be eliminated.

The patent contains four claims each of which is asserted by plaintiff as infringed by defendants' products. These claims are set out in full in the margin.[3] The first and second claims differ only in that the former indicates the CTE's of the ferrite core and the glass gap-filler are substantially equal at the temperature of use whereas the latter indicates the CTE's are substantially equal in the entire temperature range from the temperature of use to the softening point of the glass. The third and fourth claims add to the first and second a glass fillet, a small additional portion of glass within the loop formed by the ferrite parts.

Defendant Micronetics has admitted that its products contain every feature of the claims with the exception of the matched CTE's. Inasmuch as the equality of the CTE's is a

limitation of each claim, defendants assert they do not infringe. Additionally, they assert that the patent is invalid because the term "substantially equal" is indefinite and because matching of CTE's is obvious in view of the prior art.

A. Infringement

To determine whether an accused device infringes a patent, resort must be had to the claims. Infringement is made out when the accused product falls clearly within the claim. Graver Tank & Mfg. Co. v. Linde Air Products Co., 339 U.S. 605, 607 (1950).

Each of the claims specifies that the CTE's of the glass and the ferrite should be substantially equal. Turning to the Micronetics products, the following table indicates the CTE's of the glasses and ferrites at the temperature of use and the percentages by which they differ in different cores:

| Part No. | Glass Type | Glass CTE | Ferrite Type | Ferrite CTE | % Diff. |
|---|---|---|---|---|---|
| 35058 | 2109 | $7.4 \times 10^{-6}$ | LM211 | $7.2 \times 10^{-6}$ | 2.7 |
| 30239 | 2107 | $7.5 \times 10^{-6}$ | M211 | $7.3 \times 10^{-6}$ | 2.7 |
| 30152 | 1303 | $7.7 \times 10^{-6}$ | M211 | $7.3 \times 10^{-6}$ | 5.5 |
| 30331 | 1303 | $7.7 \times 10^{-6}$ | LM211 | $7.2 \times 10^{-6}$ | 6.5 |
| 30134, 30245, 30156 | 1303 | $7.7 \times 10^{-6}$ | M210 | $7.1 \times 10^{-6}$ | 8.5 |
| 30005 | 1201 | $6.3 \times 10^{-6}$ | M210 | $7.1 \times 10^{-6}$ | 11.3 |

| Part No. | Glass Type | Glass CTE | Ferrite Type | Ferrite CTE | % Diff. |
|---|---|---|---|---|---|
| 30037 | 2205 | $6.0 \times 10^{-6}$ | M210 | $7.1 \times 10^{-6}$ | 15.5 |
| 30085 | 2205 | $6.0 \times 10^{-6}$ | M211 | $7.3 \times 10^{-6}$ | 17.8 |
| 30064 | 2104 | $5.1 \times 10^{-6}$ | M211 | $7.3 \times 10^{-6}$ | 30.1 |

As can be seen, the variation in the CTE's ranges from 2.7% to 30.1%. Plaintiff asserts that all of these products infringe claim one with respect to the CTE limitation.

To determine whether Micronetics products infringe the patent, we must construe the limitation in the claims that the CTE's of the glass and ferrite be "substantially equal."

In order to construe this term, resort must be had to the specifications for it is axiomatic that claims are to be construed in light of the specifications. United States v. Adams, 383 U.S. 39, 49 (1966); Schriber-Schroth Co. v. Cleveland Trust Co. 311 U.S. 211, 217 (1940). The specifications contain the following description of the invention:

> "When the coefficients of expansion are equal to one another at the temperature at which the magnetic recorder head is used (with a tolerance of 5%), the tensions occurring in the glass are small thus preventing the production of strains in the ferrite which would also tend to facilitate chipping of the ferrite edges of the gap by the mechanical forces exerted by the operation of the magnetic recording carrier; . . . ."

The interpretation that must be placed on this language is that to practice the invention one must make the CTE's as equal as possible with a maximum allowable difference of 5%. The examples of suitable matches given by the inventor are all well within this 5% limit. Thus, the term substantially equal, as used in the claims, should be given the meaning "matched within 5%."

Turning to the accused devices, only two Micronetics heads fall clearly within the range claimed by the patent, parts numbered 35058 and 30239 and could be said to infringe.

Plaintiff argues that all the cores manufactured by Micronetics infringe under the doctrine of equivalents. Courts have recognized that infringement may be made out even though the accused device does not duplicate every literal detail of the patented invention. The test of infringement under the doctrine of equivalents is whether the device "'performs substantially the same function in substantially the same way to obtain the same result.'" Graver Tank & Mfg. Co. v. Linde Air Products Co., supra at 608. The range of equivalents to be accorded a patent varies with the circumstances of the particular case. A primary, or pioneer, invention may be accorded a broad range of equivalents whereas an improvement patent is not entitled to such a broad range of protection. 4 A. Deller, Deller's Walker on Patents, §232, at 82-83 (2d ed. 1965). Basically, the inquiry is whether the

inventive principle has been appropriated and the changes made insubstantial.

The sole claimed invention in Duinker is the discovery that ferrite gap edge-chipping may be avoided by matching the CTE's of the glass and ferrite within a tolerance of 5% at the temperature of use and 10% over the range from room temperature to the softening point of the glass. The prior art concerning magnetic recording heads is crowded and the claimed invention is narrow. To construe the range of equivalents to be accorded the Duinker patent to embrace all of the Micronetics cores would render the term "substantially equal" meaningless and would have the effect of reading it out of the patent altogether. This term is an express limitation pertaining to the inventive step and implies, in effect, that anything beyond the limitation will not produce equivalent results. Inasmuch as the inventor has declared combinations, such as those found in the accused devices, not equivalent, we cannot treat them otherwise to find infringement. See Dow Chemical Co. v. Skinner, 197 F.2d 807, 810 (6th Cir.), cert. denied, 344 U.S. 856 (1952); Preformed Line Products Co. v. Farner Manufacturing Co., 225 F. Supp. 762, 774 (N.D. Ohio 1962), aff'd, 328 F.2d 265 (6th Cir.), cert. denied, 379 U.S. 846 (1964).

Nor can a change in the match of the CTE's be considered an insubstantial alteration in the practice of the invention. The whole inventive principle in the patent lies

in the match of the CTE's. When the differences are not employed in the manner specified the inventive principle is not appropriated. Thus, although the accused devices accomplish the same result; that is, they are commercially acceptable cores free from undue chipping, they do so in a different manner. First, as plaintiff's expert testified, improvements in ferrites have to some extent reduced the chipping problem to which Duinker is directed. Second, Micronetics devices follow a different teaching. Micronetics cores are produced according to the principle that glass is strongest under compression and, thus, ferrite of a higher CTE than the glass is used. This is nowhere taught by Duinker.

Therefore, it cannot be said that all the Micronetics cores infringe plaintiff's patents under the doctrine of equivalents. The Court has examined plaintiff's other arguments in support of a finding of infringement and finds them to be without merit. Accordingly, the Court finds that only Micronetics parts numbered 35058 and 30239 infringe the Duinker patent.

B. Indefiniteness

Defendants argue that the Duinker patent is invalid because it lacks the definiteness of description required by 35 U.S.C. §112. They contend that the term "substantially equal," as used to describe the degree of CTE match, is

vague and indefinite. Further, they contend that there is no such thing as a CTE at the temperature of use and that this meaningless relationship compounds the indefiniteness of the claims and specifications.

Although the statute requires an exact description of the invention, it does not require description in terms of exact measurement. All that is required is that the claims, when read in light of the specifications, inform those skilled in the art how to practice the invention and how infringement may be avoided. Eibel Process Co. v. Minnesota & Ontario Paper Co., 261 U.S. 45, 65 (1923); Georgia-Pacific Corp. v. United States Plywood Corp., 258 F.2d 124, 136 (2d Cir.), cert. denied, 358 U.S. 884 (1958). Whether a given claim has the requisite definiteness depends upon the facts in each case. Georgia-Pacific Corp. v. United States Plywood Corp., supra.

Applying these standards to the facts of the instant case, the Court finds that the specifications and claims are sufficiently defirite to meet the statutory standard of 35 U.S.C. §112. There are many instances where claims with adverbs such as "substantially" have been upheld against a challenge of indefiniteness. See, e.g., Eibel Process Co. v. Minnesota & Ontario Paper Co., supra; Borg-Warner Corp. v. Paragon Gear Works, Inc., 355 F.2d 400 (1st Cir. 1965), petition for cert. dismissed, 384 U.S. 935 (1966); Arnold Pipe Rentals Co. v. Engineering Enterprises, Inc., 350 F.2d

885 (5th Cir. 1965); H. H. Robertson Co. v. Klauer Mfg. Co. , 98 F.2d 150 (8th Cir. 1938). Thus, such terminology is certainly not indefinite as a matter of law.

Defendants rely on expert testimony, arguing that neither side's expert could precisely define what was meant by "substantially equal" as used in the claims. However, the Court does not view the testimony of either expert as persuasive on this particular point. Rather, the patent speaks for itself.

The Court finds that the term "substantially equal" as used in each claim of the patent is not so indefinite as to render the patent invalid.

Nor does the discussion of matching CTE's at the temperature of use, when added to the imprecision of the term "substantially equal" render the patent invalid under §112. The premise underlying Duinker's invention is that edge-chipping results from the heat generated by the movement of the recording head over the magnetic medium. Defendants' expert testified that the CTE at any given temperature was meaningless, that one needed a range between one temperature and another. Although the patent speaks of the "temperature of use," or room temperature, it is clear from the patent as a whole, particularly the examples given, that this refers to the range of temperature between 0°C and

40°C. Thus, the claims dealing with the CTE's of the glass and ferrite at the temperature of use are not meaningless.

C. Obviousness

The principal question raised with respect to the validity of the Duinker patent is whether the invention would have been obvious at the time it was made to a person having ordinary skill in the art. 35 U.S.C. §103. Resolution of the question requires application of the procedure set out in Graham v. John Deere Co., 383 U.S. 1 (1966). That is:

> Under §103, the scope and content of the prior art are to be determined; differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background, the obviousness or nonobviousness of the subject matter is determined. Such secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. As indicia of obviousness or nonobviousness, these inquiries may have relevancy.
> Id. at 17-18.

The parties agree that this is the standard to be applied. They disagree, however, on what constitutes the pertinent prior art and on the conclusion this Court should reach in applying the agreed standard to the prior art.

1. Scope and Content of the Prior Art

Defendants cite as pertinent prior art U.S. Patent Nos. 2,071,196 to Burger et al.; 2,167,482 to Hull et al.; 2,371,627 to Kingston; an article by Chynoweth,

dated August, 1955 and a German publication entitled "The Methods of Fusing Ceramics to Glass and Metal," dated 1942. They argue that these authorities fully disclose that which Duinker claimed as his invention. Plaintiff, on the other hand, contends that each of these authorities is merely concerned with achieving good bonding and that none discloses information which would make it obvious to one skilled in the art to match CTE's of the glass and ferrite to an extent closer than that needed to achieve good bonding in order to alleviate ferrite gap edge chipping. A closer examination of each of the cited items is necessary.

The Burger Patent

This patent, issued in 1937, concerns glass-to-metal-seals in general. It is directed at resolving the problem posed by failure of the seal in use, although a good seal may have been initially created. According to the patent, differences in the CTE's of the glass and metal introduce strains in the seal which result in fissures or cracks in the glass. In the language of the patent,

> In the prior seals, the glass and metal members, even though they may have had substantially the same coefficients of expansion at room temperature, have had different thermal expansions at the different temperatures involved in the process of making the seals and these members have undergone individual expansions and contractions in size

> during the heating and cooling cycles. Consequently, such seals have involved strains introduced at the higher temperatures which were carried through to the lower temperatures. Even though these residual strains may not have been greater than the elastic limit or breaking strength of the glass, depending upon the amount and kind of metal employed, at the time the seal was made, there has always been the possibility that the seal might eventually fail due to aging of the glass and the reduction of its elastic limit over a period of time, and many failures may be attributed to this cause. In view of these considerations, it is evident that none of the seals of the prior art has been entirely free from strain over the whole temperature range between room temperature and the softening temperature of the glass.
>
> * * *
>
> Even though this strain is not sufficient to produce cracks or fissures at the time the seal is made, the glass is weakened at the joint and the seal is much more liable to failure, when the tube is operated at elevated temperatures, or even when it is idle and at room temperature. It is apparent that when an electric discharge tube of which the seal constitutes a part of the envelope is heated during operation, the temperature reached may be one of those temperatures at which there is a substantial difference in the respective thermal expansion coefficients of the glass and metal. This difference of expansion may serve to accentuate the residual strain or perhaps introduce additional strains.

As a solution to the problem of strain in glass-to-metal seals, the patent discloses that the CTE's of the glass and metal should "substantially coincide" at room

temperature and through the temperature range to the softening point of the glass. The patent discloses a metal alloy and a glass having this characteristic. The graph which illustrates the invention shows the CTE's of these materials as matched to a degree of equality even closer than that disclosed by Duinker.

The Hull Patent

This patent, issued in 1939, on an application filed in 1936, is for an improvement in the glass-to-metal seal disclosed by Burger. It discloses new metal alloys and glasses which when combined in a seal will have "substantially corresponding" CTE's. The CTE graphs which illustrate the invention show a CTE match approaching identity and closer than that disclosed by Duinker.

The Kingston Patent

Issued in 1945, on an application filed in 1939, this patent relates to metal alloys and glasses for use in forming vacuum tight seals over long periods and over a wide temperature range. It likewise discloses the importance of matching the CTE's of the glass and metal up to the softening point of the glass.

The Chynoweth Article

Entitled "Ferrite Heads for Recording in the Megacycle Range," this article appeared in the August, 1955 issue of Tele-Tech & Electronic Industries. The article reports on research conducted with ferrite recording heads.

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Specifically, it concerns the wearing quality of ferrite heads with short gap lengths used in contact with a magnetic medium. According to the article, the gap edges chipped in use and this poor wearing quality represented a serious deficiency in ferrite heads. The article then discloses that:

> A technique which holds some promise, [for decreasing this gap edge erosion] is to fill in the gap with a glaze material which is non-magnetic, bonds well to the gap faces and is hard.

According to the article such a head was constructed and the glazing technique was successful in increasing the head's resistance to wear.

The German Article

This article, concerning the methods of fusing ceramics to glass and metal, appeared in the German publication Keramische Rundschau in 1942. The article discloses that when bonding glass and ceramic, "no stresses will exist between the two materials only if the expansion curves have exactly the same course." Since this ideal is not practically attainable, the author suggests using a ceramic with a higher CTE than the glass.

2. Differences Between the Prior Art and the Claimed Invention

From the above recitation, it is apparent that all the individual elements claimed in the Duinker patent are

shown by the prior art. However, no single item of the prior art shows the whole Duinker invention.

Defendants contend that the German article when read with the Chynoweth article fully discloses the Duinker invention. Plaintiff argues, on the other hand, that the German article was published before the development of ferrites and, thus, does not apply to ferrites. Further, plaintiff argues that Chynoweth does not disclose a gap completely filled with glass but merely glazed gap surfaces. Above all, plaintiff argues that none of the prior art references discloses that ferrite head edge-chipping is caused by unequal CTE's and that the solution lies in matching the CTE's to a degree closer than that necessary to attain a good bond.

Comparing the prior art with the claimed invention, as the Court must, the Court finds the following differences between the Duinker patent and the prior art: The patents to Burger, Hull, and Kingston disclose the importance of matching CTE's very closely to obtain strain-free glass-to-metal bonds. However, none of these patents deal with ferrites. Although they disclose that failure of the bond will result from use, if CTE's are not matched to substantial equality, in practical application the failure results in cracking of the glass in glass-to-metal bonds. Thus, they do not read exactly on the problem faced by Duinker.

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The German article is concerned with bonding glass to ceramics, generally. It discloses that ideally CTE's should be equally matched to achieve a good bond. It is true that the article was written prior to the development of ferrites; however, it is undisputed that ferrite is a ceramic. Given this agreed fact and the article's concern with ceramics in general, the German article reads directly on the Duinker invention insofar as it indicates the desirability of matching CTE's in glass-to-ceramic bonds. It does not, however, disclose the more particular application of this principle claimed by Duinker.

The Chynoweth article does disclose glazing in the gap as a solution for improving the wearing problems in ferrite core gap edges. It is silent, however, on the CTE's of the materials used.

Plaintiff seeks to make much of these differences. As noted above, no one item of prior art fully discloses the Duinker invention. However, the proper standard to be applied is not whether the prior art fully discloses the precise invention claimed, but rather whether, in light of this prior art, the claimed Duinker invention would be obvious to one skilled in the art. See, e.g., Koppers Co. v. S & S Corrugated Paper Machinery Co., 517 F.2d 1182 (2d Cir. 1975);

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Julie Research Laboratories, Inc. v. Guildline Instruments, Inc., 501 F.2d 1131 (2d Cir. 1974); Formal Fashions, Inc. v. Braiman Bows, Inc., 369 F.2d 536 (2d Cir. 1966).

Applying this standard to the facts of this case, the Court holds that the Duinker patent is invalid for obviousness in light of the prior art. First, Burger fully discloses that in glass-to-metal bonds failure occurs in use, even though a good bond is achieved in manufacture, if the CTE's of the glass and metal are not nearly equal, not only at room temperature but throughout the entire temperature range from room temperature through the softening point of the glass. Burger fully discloses that the heat generated in use elevates the temperature sufficiently to result in failure of the bond unless the CTE's are so matched. The prior art in making glass-to-metal bonds demonstrates that it was well known that CTE's should be closely matched to achieve good wearing qualities in use.

Plaintiff argues that the problems posed by glass-to-metal bonds are not analogous to those encountered by Duinker and these items should not be considered prior art. Plaintiff stresses that in glass-to-metal bonding the concern is with the glass whereas the glass is not a problem in bonding glass to ferrite.

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Prior to the introduction of ferrites, magnetic recording heads were constructed of metal, often metal laminations. In the Duinker patent file wrapper, the Court finds at least one instance where glass was bonded to the metal pole pieces of such a metal head in order to join the two pole pieces. Thus, it appears that bonding glass to the metal heads was known in the magnetic recording head field.

Also, in light of the German article it would have been obvious that there were no significant differences with regard to the role of CTE's between ceramic-to-glass bonds and metal-to-glass bonds.

The patent examiner considered glass-to-metal bonds to be prior art in considering the patentability of the Duinker invention. The Court is constrained to likewise consider it. The only testimony presented at trial on the question is found in the conflicting opinions of the experts who testified on behalf of the respective parties. The Court is unpersuaded that the problem of ferrite gap edge chipping is completely different from the problem of glass breakage. Both are caused by strains in the bond. In glass-to-metal bonds the metal is not likely to crack or chip, therefore, it is the glass which suffers the effect of the strains. The inherent granularity of ferrite was well known and it seems

obvious that the strains known to be in the bond would cause the ferrite to chip.

Thus, when one considers the disclosures of Burger together with the teaching of the German article, it would be obvious that making the CTE's substantially equal would alleviate chipping of the ferrite. When these references are read together with the Chynoweth article, the invention claimed by Duinker becomes an obvious solution to the problem of making ferrite cores for recording heads with good wearing qualities.

Plaintiff relies on the presumption of validity accorded a patent. In the Second Circuit the presumption of validity is weakened when the patent examiner did not consider all of the pertinent prior art. See, e.g., Julie Research Laboratories, Inc. v. Guildline Instruments, Inc., supra; Formal Fashions, Inc. v. Braiman Bows, Inc., supra. In the instant case, the patent examiner did not consider the Burger patent or, most important, the German article. Thus, the presumption of validity to be accorded the Duinker patent is considerably weakened.

In addition, plaintiff relies on the secondary considerations enunciated in Graham v. John Deere Co., supra as indicia of the non-obviousness of the Duinker invention. Because of the danger of slipping into hindsight and reading

into the prior art the teachings of the Duinker invention, the Court has considered the evidence of commercial success and long-felt but unsolved need. This inquiry has served only to reinforce the Court's judgment that the Duinker patent is obvious in view of the prior art.

First, plaintiff introduced no evidence of contemporaneous commercial success. The only evidence introduced relevant to this issue concerns the use at the time of the action of the Duinker invention by Ferroxcube Corporation, a wholly-owned subsidiary of ~~plaintiff~~ North American Philips Corporation which manufactures glass bonded ferrite recording heads, and Micronetics. However, none of the cores produced by Ferroxcube utilize the Duinker invention, according to the Court's construction of the patent, and the majority of Micronetics' products, also, fall outside the invention. 2-10-76 R.J.W.

Likewise, there is no evidence of any long felt want. Ferrites were first introduced around 1950 and Duinker first filed for his patent in 1955. The evidence indicates that this was a crowded art with considerable activity during this period. The witnesses who testified painted a picture of a milieu where as soon as one group of researchers discovered a problem others set about solving it. Cf., Julie Research Laboratories, Inc. v. Guildline Instruments, Inc., supra; Indiana General Corp. v. Krystinel Corp., 421 F.2d 1023, 1030-31 (2d Cir.), cert. denied, 398 U.S. 928 (1970).

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In sum, the Court holds that the patent [illegible] is invalid for obviousness in light of the prior art. There may be some novelty in the Duinker invention but novelty is insufficient to meet the non-obvious requirement of §103 when the novel element would have been obvious to a person skilled in the art. See Lemelson v. Topper Corp., 450 F.2d 845 (2d Cir. 1971), cert. denied, 405 U.S. 989 (1972).

Next, the Court turns to the Peloschek patent.

V. The Peloschek Patent

The Peloschek patent, issued April 19, 1966 on an application filed May 3, 1963, is directed to a process for manufacturing bonded magnetic recording heads of a kind described by Duinker. The patent addresses itself to the problems of manufacturing magnetic recording heads with very short gap lengths, simply, and achieving close gap length tolerances.[4] The patent teaches that if the gap is pre-set by placing the two magnetic pole pieces in a confronting relationship with the interposition of a shim, or spacing member, equal to the desired gap length and the glass is placed adjacent to the pre-set gap and the assembly is heated, the glass will flow into the gap by capillary action and fill it, thus, producing a core with the desired gap length.

The patent contains fifteen claims. With the exception of claims 7, 12 and 13, all are assertedly infringed

by defendants. The claims in issue are set out in full in the margin.[5] The several claims differ from each other only in minor respects. Claim 10 is the broadest claim and comprises a method whereby the two confronting circuit parts or pole pieces are separated by a space equal to the desired gap length, the non-magnetic material is placed adjacent to the gap, and the assembly is heated to the melting temperature of the glass so that the gap is filled by capillary action. Claim 1 differs from claim 10 only in that it recites that the unfilled gap is pre-fixed by the placing of a spacing member or shim between the confronting pole pieces. Claim 5 adds to claim 1 the step of thermally etching the circuit parts before they are placed in a confronting relationship. Claim 6 is like claim 1 with the addition that the finished assembly is cut perpendicularly to form a plurality of cores. The remaining claims variously recite that the non-magnetic material is either glass or enamel or that pressure is applied during heating.

Defendant Micronetics admits that its products contain every feature of the claims with the exception of the gap space or spacer being equal to the desired gap length and the thermal etching step. Inasmuch as the equality of the shim and the desired gap length is a limitation of each claim, defendants assert they do not infringe. Additionally,

they assert that the patent is invalid because the term "equal to" is indefinite and because the claimed invention is obvious in view of the prior art.

A. Indefiniteness

As with the Duinker patent, defendants argue that the Peloschek patent is invalid because it lacks the definiteness of description required by 35 U.S.C. §112. They contend that the term 'equal to" as used to describe the relationship between the spacer and the desired gap length is without ascertainable meaning.

The Court finds that the specifications and claims are sufficiently definite to meet the statutory standard. As already noted, the gap dimensions are exceedingly small and absolute precision in measurement cannot always be achieved. Just as a certain tolerance is acceptable in terms of the final core, an equivalent tolerance should be permitted with regard to the shim. The claims, when read with the specifications more than adequately inform those skilled in the art how to practice the invention and how to avoid infringement.

B. Obviousness

As with the Duinker patent, the principal challenge raised by defendants to the validity of the Peloschek patent is that the invention would have been obvious at the time it was made to a person having ordinary skill in the art.

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Thus, it is necessary to examine the scope and content of the prior art and the differences between the prior art and the Peloschek claims.

1. Scope and Content of the Prior Art

Defendants cite as pertinent prior art U.S. Patent Nos. 2,500,748 to Grant; 3,024,318 to Duinker et al.; 3,029,505 to Reichenbaum; 3,094,772 to Duinker; 3,117,367 to Duinker et al.; 3,283,396 to Pfost; 3,304,358 to De Jean et al.; 3,341,939 to Feinberg et al.; 3,065,571 to Hill; German Patent 10546; and two German articles. Defendants contend that in light of this prior art the use of capillary action to manufacture glass bonded ferrite cores would have been obvious and represented merely routine engineering. Plaintiff, on the other hand, contends that all the cited prior art which is relevant to the problem points toward the non-obviousness of the patented invention and that none shows the capillary process in the recording head industry.

The Three Duinker Patents

Duinker '318 is the patent here in suit and discussed above. The method of manufacturing the invention disclosed by the patent consists of placing a glass foil which exceeds in size the ultimately desired gap width by a few percent between two confronting polished ferrite gap surfaces. This assembly is then heated to a temperature within the softening range of the glass and pressure is applied until the correct gap-width is reached. This can be referred to as the

"sandwich" technique. Relevant, also, is a method of manufacturing the glass fillet consisting of placing a glass rod inside the ferrite loop near the gap so that during heating the glass spreads to form the fillet.

Duinker '722, issued June 25, 1963 on an application filed June 26, 1957, discloses merely a further refinement and expanded discussion of the manufacturing technique disclosed in the first Duinker patent. Additionally, it includes the disclosure of slicing the ferrite glass assembly to form a multiplicity of cores.

Duinker '367, issued January 14, 1964 on an application filed June 15, 1959, discloses a further refinement of the sandwich technique by the addition of shims or spacers, " the thickness of these spacers being substantially equal to the finally desired gap length." The description explains that the spacers were intended to alleviate the problem of glass flowing away in heads with a gap length of greater than 10 microns. The function of the spacers is to fix the gap length. They are placed at the ends of the sheet of glass and between the ferrite bars prior to the heating and compression steps and are then ground away after cooking.

The Pfost Patent

This patent, issued November 8, 1966 on an application filed April 17, 1961, exemplifies another variation of the sandwich technique. The method disclosed consists of

depositing spacer strips on one ferrite surface and a thin layer of glass on the other ferrite surface, placing the two ferrite surfaces in a confronting relationship, and heating the assembly to a temperature of 550-900 degrees centigrade under high pressure. The patent, also, discloses heating the ferrite blocks to a temperature of 600 degrees centigrade prior to coating with either glass or spacer in order to remove contaminants. Of significance to this litigation is the disclosure in the specifications that at temperatures between 550-900 degrees centigrade, glass will wet the ferrite.

The Hill Patent

This patent, issued on November 27, 1962 on an application filed October 10, 1957, concerns a composite material of platinum alloy and glass for use in making glass-to-metal seals. The parties are in dispute as to what this patent discloses. Defendants contend that the patent discloses that capillary action is a customary method for bonding glass and metal. Plaintiff argues capillarity is discussed in general terms. The Court finds that capillary action is discussed in general terms as the physical principle which is the foundation for the invention. The patent discloses that glass is a liquid and will behave as a liquid insofar as capillary action is concerned. Thus, in order to achieve a good glass-to-metal bond, the patent claims

an alloy which exhibits superior wetting action.

Prior Art Processes Utilizing the Principle of Capillary Action

A group of defendants' prior art references may be conveniently categorized as illustrations of the use of capillary action in connection with manufacturing processes with materials other than glass and ferrite.

The patent to Reichenbaum, issued April 17, 1962 on an application filed September 29, 1958, falls into this category. It discloses the process of bonding a semiconductor to a metal base, a heat sink, by means of flowing solder between the two parts by capillary action. A small quantity of solder is placed adjacent to the empty space between the two materials and on melting flows into the space.

The patents to De Jean, Feinberg, and the German patent all disclose the process of manufacturing a laminated magnetic core by flowing non-magnetic resins into the minute space between the laminations by capillary action. The German patent, in particular, is for manufacturing metal laminated recording head cores.

The Grant patent, issued March 14, 1950 on an application filed November 21, 1947, concerns a method for manufacturing magnetic structures consisting of two or more magnetizable members separated by a non-magnetic gap. According to the claims, the invention comprises:

> 2. In a magnetic structure, a first magnetizable member provided with a mortise, a second magnetizable member having a projection thereon forming a tenon, said two magnetizable members being interfitted to form a mortise and tenon joint, a washer of low melting point non-magnetizable material brazed between said members adjacent said joint, and a capillary film of said non-magnetizable material brazed between contiguous surfaces of said mortise and tenon, thereby rigidly to connect said magnetizable members together and to form therebetween a permanent non-magnetic gap of fixed dimensions.

In plain English, the patent discloses a structure consisting of two magnetic parts separated by a minute permanent non-magnetic gap, which also bonds the two together, created by flowing non-magnetic material between the two parts by capillary action.

2. Differences Between the Prior Art and the Claimed Invention

From the preceding recitation, it is apparent that no one item of prior art discloses the whole of the Peloschek process. Defendants contend, however, that the use of capillary action to fill spaces was well known and that it was an obvious solution to the problem of filling the non-magnetic gap in ferrite recording head cores. They contend that when the prior art disclosures concerning capillary action are read together with the disclosures of the Duinker patents, Peloschek results.

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The most apparent difference from the Duinker patents process is that Duinker uses pressure to fill the gap rather than capillary action. Consequently, Duinker places the glass inside the gap rather than adjacent to it. However, Duinker does disclose the use of shims to determine the final gap length. Plaintiff makes much of the difference it perceives between the use of the shims in connection with setting the gap prior to the introduction of the glass in Peloschek and the use of the shims to keep the ferrite slabs apart during compression in Duinker. The Court finds this to be a difference without substance. In both patents the shims are equal or substantially equal to the ultimately desired gap length, they are placed between the two ferrite pieces to keep them a fixed distance apart.

Duinker, also, discloses that glass will wet ferrite. If one looks at the diagram in Duinker '772, one can clearly see the miniscus formed by the glass fillet. Wetting action of this sort is necessary for capillary action and the degree of surface tension as indicated by the miniscus and the wetting angle formed by the miniscus are crucial variables in determining the extent of capillary flow. *6

The Pfost patent, so far as is relevant here, does not materially differ from the Duinker process. It, also, uses pressure to fill the gap with glass and spacers to determine the gap length. It does not speak to the use of capillary action to fill the gap, except that it notes that glass will

wet ferrite at temperatures ranging from 550-900 degrees centigrade. It discloses a preliminary step of heating the ferrite to a temperature of 600 degrees solely to eliminate contaminants. However, this step cannot be equated with the thermal etching step at significantly higher temperature disclosed by Peloschek.

The Hill patent does not speak to a process of manufacturing magnetic recording heads. The only relevance it has to this litigation is its disclosure that glass is a liquid and will behave in accordance with the principles of capillary action.

The capillary action prior art, De Jean, Feinberg, and the German patent, differ from the Peloschek invention in that in each the precision and reproducibility of the gap length is not critical. Rather, the spaces to be filled are random. The substance of the Peloschek invention, in contrast, is directed at attaining reproducible minute gaps within close tolerances.

The claims of the Grant patent seem to read most directly on the Peloschek method. The two distinguishing features are the circular configuration of the magnetic members and the apparent irrelevance of the size of the gap. Although in Grant the space between the magnetic members is fixed in size at the conclusion of the process, there is no attempt to attain a predetermined gap size.

Thus, it is apparent that none of the prior art shows all the elements of the Peloschek process. The differences between the Duinker "sandwich" process and the Peloschek process are that the glass is moved from inside the gap to just adjacent to it and that instead of only one ferrite face being in contact with the shims both are. In the former, pressure is used to force the glass to fill the gap whereas in the latter capillary action does the job. The prior art indicates the widespread use of capillary action to fill minute gaps but in none is the precise size of the gap of great importance or predetermined. The question, however, is not whether the precise invention is disclosed by the prior art, for then there would be no novelty, but rather whether in light of the prior art the invention as a whole would be obvious to one skilled in the art. Graham v. John Deere & Co., supra; Koppers Co., Inc. v. S&S Corrugated Paper Machinery Co., supra; Julie Research Laboratories, Inc. v. Guildline Instruments, Inc., supra; Formal Fashions, Inc. v. Braiman Bows, Inc., supra.

In order to apply this standard, the level of skill in the pertinent art must be ascertained. Plaintiff contends that the pertinent art is that of magnetic recording, particularly ferrite recording heads. Defendants, on the other hand, contend that the pertinent art is the glass or glass and

ceramic bonding technology. The Court finds that the pertinent art is the glass and glass bonding art. The problem to which the Peloschek patent is directed is that of manufacturing rather than high frequency recording technology. The problems posed by developing an economical method of manufacture were mechanical problems of working with glass and bonding glass to ferrite. Recording head efficiency and design were not the immediate concern of the Peloschek patent and the patent contains no disclosures directed toward improving ferrite recording head efficiency and design. Accordingly, the most pertinent art to the problem posed is that of glass bonding technology.

Although the question is a close one, the Court holds that the Peloschek invention would not have been obvious to one skilled in the art at the time it was made. The crucial feature, in the Court's view, is the use of capillary action to fill a preset gap of precise, reproducible dimensions. Nowhere in the prior art references cited to the Court is there any disclosure which would make it clear to one skilled in the art that such an application of capillary action would be successful. All of the prior art references disclose the use of capillary action to fill random voids. In none were the dimensions of the void of great importance. The mechanical skill of the calling consists, then, in using capillary action to fill voids the precise dimensions of which are unimportant.

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Inasmuch as the primary concern of the Peloschek invention is filling a gap whose precise dimensions are significant, it cannot be said that Peloschek is obvious within the standard of 35 U.S.C. §103.

Defendants had the burden of establishing their defense of patent invalidity for obviousness. After reviewing all the evidence, the Court concludes they have failed to sustain their burden. It is easy to argue, as defendants do, with the always perfect vision of hindsight that the Peloschek invention is fully anticipated by the prior art. For example, once one concludes that capillary action, as disclosed by Grant, can be successfully applied, it is obvious to take Duinker and merely move the glass outside the gap and place the ferrite pole pieces in a confronting relationship.

However, the fact remains that the prior art does not suggest that capillary action would successfully produce gaps of precise predetermined size with reproducibility. Indeed, the Grant patent was issued in 1950 and presumably this prior art was available to Duinker and the others who sought a method for manufacturing ferrite recording heads. Nonetheless, approximately seven years passed from the filing of Duinker's original patent application to the filing of

Peloschek's patent application. During that period, the record discloses four patents for manufacturing glass bonded ferrite recording heads: the two later Duinker patents and the Pfost patent discussed above and a patent to M. Camras, U.S. Patent No. 3,079,470 filed December 21, 1959 and issued February 26, 1963, cited by the patent examiner.[7] Each of these patents utilizes the "sandwich" process of introducing the glass into the gap by pressure. None suggests employing capillary action. Thus, as simple as the invention now appears, the Court cannot conclude that it was obvious to persons skilled in the art when the record discloses that these others endeavored during the seven year period to solve the problem unsuccessfully. As the court in Timely Products Corp. v. Stanley Arron, 523 F.2d 288, 294 (2d Cir. 1975) said:

> We can conceive of no better way to determine whether an invention would have been obvious to persons of ordinary skill in the art at the time than to see what such persons actually did or failed to do when they were confronted with the problem in the course of their work. If the evidence shows that a number of skilled technicians actually attempted, over a substantial period, to solve the specific problem which the invention overcame and failed to do so, notwithstanding the availability of all the necessary materials, it is difficult to see how a court could conclude that the invention was "obvious" to such persons at the time.

Admittedly, the evidence of the "secondary" indicia of non-obviousness is meager. Plaintiff presented some evidence which would tend to indicate that the Peloschek process has

enjoyed a degree of contemporaneous commercial success. For example, as will appear more fully below, both Micronetics and Ferroxcube use the capillary process. N.V. Philips, whose employees developed the invention, also, makes some use of the process. There is, also, some testimony indicating that IBM made use of the process at least until 1969. In light of the record, the Court has not attached great weight to the proof offered of commercial success. Nonetheless, the failure of other skilled workers in the field has persuaded the Court to resolve any lingering doubt in favor of upholding the validity of the patent.

Accordingly, the Court holds that the Peloschek patent is valid and non-obvious under §103.

C. Infringement

As with the Duinker patent, the Court must look to the claims of the Peloschek patent and determine whether the Micronetics process falls clearly within the claims in order to decide whether Micronetics infringes the patent. Graver Tank & Mfg. Co. v. Linde Air Products Co., supra at 607. Defendants contend only that the Micronetics process does not include the thermal etching step and shims "equal to" the desired gap length.

Each of the claims recites that the spacing members "are equal to" the desired gap length. Turning to the Micronetics products, the following table indicates the relationship

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between the shim heights and the gap length desired by the customer for the various Micronetics part numbers:

| A<br>Shim Height | B<br>Desired Gap Length | C<br>Illustrative Part No. | D<br>Illustrative Bonded Bar No. | E<br>I-Bar No. |
|---|---|---|---|---|
| .0029"-.003" | .0024"-.0036" | 30134 | 30162 | |
| 114-118u" | 80-115u" | 30093 | 30104 | 40003 |
| 114-118u" | 80-120u" | 30316 | 30104 | 40003 |
| 114-118u" | 85-115u" | 30037 | 30104 | 40003 |
| 114-118u" | 95-120u" | 30041 | 30104 | 40003 |
| 114-118u" | 90-120u" | 30005 | 30101 | 40003 |
| 115-117u" | 85-115u" | 30023 | 30107 | 40017 |
| 115-117u" | 90-110u" | 30064 | 30107 | 40017 |
| 115-117u" | 90-120u" | 30060 | 30103 | 40025 |
| 158-164u" | 130-160u" | 30280 | 30182 | 40074 |
| 542-562u" (Write Gap) | 450-550u" | 30245 | 30309 | 40086 |
| 147-157u" (Read Gap) | 100-150u" | 30245 | 30309 | 40086 |
| 500-560u" | 400-600u" | 30156 | 30155 | 40037 |
| 60-64u" | 45-65u" | 35012 | 35021 | 45014 (C-Bar) |

Column B in the table represents the gap length desired by the customer. As can be seen, all of the specified customer gap lengths are given as a range. Precision of measurement at these minute dimensions is not possible. Thus, there is always a certain tolerance, or permissible deviation, from

any precise numerical value. As can be seen from Column A, all the Micronetics products fall within the specified range or outside the range by a few micro-inches. The only possible exception to this may be the "write gap" of part number 30245 in which the upper range of the shim height exceeds the upper range of the gap desired by 12 micro-inches. In light of the allowances which must be made for the imprecision of measurement, the shim height must be deemed equal to the desired gap length when it falls within the customer's specified range or outside the range by only a few micro-inches.

Defendants contend that the height of the shims exceeds the desired gap length and that the shims are compressed during the manufacturing process. Even if the Court could agree with this contention, which it does not, it would still be constrained to conclude that the Micronetics shims are equal to the desired gap because they fall within or close to the specified range. Accordingly, the Court holds that the Micronetics manufacturing process infringes claims 1 through 4, 6, and 8 through 11 of the Peloschek patent. Insofar as the "write gap" of part number 30245 may not be deemed as falling literally within or close to the desired gap length range, the Court holds that the deviation is so insubstantial as to be the equivalent of the Peloschek invention and thus infringes under the doctrine of equivalents.

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Graver Tank & Mfg. Co. v. Linde Air Products Co., supra.

Claims 5, 14 and 15 contain, as a further limitation, the preliminary step of thermally etching the ferrite bars prior to assembly. Thermal etching as used in the patent is the process whereby the ferrite bars are heated to a temperature of between 800 and 1000 degrees centigrade for a period of time and then allowed to cool producing ferrite grain boundaries which are visible with the assistance of the proper equipment. Defendants employ a preliminary "bake out" step for a combination of temperature and time which is less than that which produces visible grain boundaries. They contend that their "bake out" step is merely to remove contaminants and does not constitute thermal etching.

The Court finds that plaintiff has failed to sustain its burden of proof of infringement of those claims which include the thermal etching step. One of the co-inventors testified that thermal etching as used in the patent refers to producing visible ferrite grain boundaries. Photographs of Micronetics' ferrites after the "bake out" step were introduced into evidence and they do not exhibit the grain boundaries visible in thermally etched cores. Additionally, the Pfost patent discloses a pre-heating step such as that performed by Micronetics for the purpose of removing contaminants. Accordingly, the Court concludes that the Micronetics process

does not include the thermal etching step and that claims 5, 14 and 15 of the Peloschek patent are not infringed.

VI. Liability of Ned W. Buoymaster

Defendant Buoymaster is president of Micronetics and one of the four founders of the corporation. Plaintiff contends that Buoymaster actively induced the infringement of the two patents in suit and is personally liable as an infringer.

A corporate officer is generally not personally liable for an infringement when he acts solely within his duties as an officer and director. Powder Power Tool Corp. v. Powder Actuated Tool Co., 230 F.2d 409, 414 (7th Cir. 1956); Claude Neon Lights, Inc. v. American Neon Light Corp., 39 F.2d 548 (2d Cir. 1930); Upjohn Co. v. Italian Drugs Importing Co., 190 F.Supp. 361 (S.D.N.Y. 1961).

> However, where a corporate officer exceeds his executive duties and deliberately organizes a corporation for the purpose of infringing a patent, or where he otherwise acts as the moving active conscious force behind an infringement, he may be held personally liable.
> Upjohn Co. v. Italian Drugs Importing Co., supra at 367.

See also, Marks v. Polaroid Corp., 237 F.2d 428, 435 (1st Cir. 1956).

Buoymaster founded Micronetics, along with three others, in April, 1969. The evidence establishes that the

corporation was formed to produce materials, including ferrites, for use in highly technical electronics applications. There is no evidence to suggest that Micronetics was formed with the specific intent to manufacture glass-bonded ferrite recording heads. Nonetheless, soon after the formation of the corporation, it entered the market for glass-bonded ferrite cores.

Buoymaster is a large shareholder in Micronetics, although by no means a majority shareholder, and serves on the four man Board of Directors which manages the corporation.

Plaintiff has failed to sustain its burden of proving that Buoymaster acted in excess of his authority as an officer and director of Micronetics. The evidence shows only that Buoymaster was the chief administrative officer of the corporation. As such he was involved in the business aspects of corporate affairs and not in the technical production phase. He may have made the decision to offer for sale glass-bonded ferrite heads but he was familiar with the manufacturing process only in a general way. He in no way directed or instigated the infringing method of manufacture. Compare Marks v. Polaroid, supra; Dean Rubber Mfg. Co. v. Killian, 106 F.2d 316, 320 (8th Cir. 1939), cert. denied, 308 U.S. 624 (1940).

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There is no evidence to suggest that Buoymaster willfully participated in the infringement of plaintiff's patent. Accordingly, the Court holds that Buoymaster is not personally liable for infringement.

VII. Conclusion

In sum, plaintiff is entitled to judgment declaring Peloschek patent claims 1, 2, 3, 4, 6, 8, 9, 10 and 11 valid and infringed, and claims 5, 14 and 15 valid but not infringed. Additionally, plaintiff is entitled to a permanent injunction prohibiting infringement of the Peloschek patent. Defendants are entitled to a judgment declaring the Duinker patent invalid. The stay of the counterclaims is vacated and the parties are directed to proceed to the adjudication of the counterclaims and the issue of damages.

The foregoing constitutes the findings of fact and conclusions of law of the Court for the purposes of Rule 52, Fed. R. Civ. P.

Settle judgment on notice.

Dated: January 27, 1976

Robert J. Ward
U. S. D. J.

OPINION

NOTES

1 Ferrites are non-metal magnetic materials composed of zinc oxide, iron oxide, etc., which is mixed in powdered form and compressed and heated at high temperatures so that the separate particles fuse to form one solid body.

2 Sometimes referred to as the coefficient of thermal expansion, this term refers to the expansibility of a material upon change in temperature, measured as the change in length for a given temperature change divided by the total length.

3 The claims of the Duinker patent are:

> 1. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising at least two circuit parts of sintered ferromagnetic oxide material with an effective gap between said circuit parts, said gap being filled entirely with a glass material mechanically joining and bonding to each other said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material having a coefficient of expansion substantially equal to the coefficient of expansion of said sintered ferromagnetic oxide material at the temperature at which the magnetic recorder head is used.
>
> 2. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising at least two circuit parts of sintered ferromagnetic oxide material with an effective gap between said circuit parts, said gap being filled entirely with a glass material mechanically joining and bonding to each other said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material having a softening temperature, said glass material also having a coefficient of expansion substantially equal to the coefficient of expansion of said sintered ferromagnetic oxide material throughout the entire temperature range lying between the temperature at which the magnetic recorder head is used and the temperature at which the glass begins to soften.

OPINION

3. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising at least two circuit parts of sintered ferromagnetic oxide material having inner and outer surfaces with an effective gap between said circuit parts, said gap being filled entirely with a glass material mechanically joining and bonding to each other said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material and said circuit parts forming a closed annular space, part of said glass material extending into said space in contact with the inner surfaces of said ferromagnetic oxide material, said glass material having a coefficient of expansion substantially equal to the coefficient of expansion of said ferromagnetic oxide material at the temperature at which the magnetic recorder head is used.

4. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising at least two circuit parts of sintered ferromagnetic oxide material having inner and outer surfaces with an effective gap between said circuit parts, said gap being filled entirely with a glass material mechanically joining and bonding to each other said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material having a softening temperature, said glass material and said circuit parts forming a closed annular space, part of said glass material extending into said space in contact with the inner surfaces of said ferromagnetic oxide material, said glass material having a coefficient of expansion substantially equal to the coefficient of expansion of said ferromagnetic oxide material throughout the entire temperature range lying between the temperature at which the magnetic recorder is used and the temperature at which the glass begins to soften.

4 "Close tolerance" refers to the small degree of deviation from the desired gap length or the slight "margin of error." Inasmuch as the patent speaks of gap lengths of 1 to 20 microns, the acceptable deviation, or tolerance, is very slight.

5 1. A method of manufacturing portions of magnetic heads composed of two magnetic circuit parts consisting of sintered oxidic ferromagnetic material and having confronting gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: placing

spacing members having a thickness equal to the desired gap length at opposite ends of a first polished gap surface of one circuit part, placing a corresponding polished gap surface of a second circuit part on said spacing members in confronting relationship with said first surface thereby forming a gap between said surfaces, placing a quantity of nonmagnetic material adjacent to the gap, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gap by capillary action, and bonds the circuit parts together.

2. A method according to claim 1, wherein said nonmagnetic material is glass.

3. A method according to claim 1, wherein said nonmagnetic material is enamel.

4. A method according to claim 1, wherein pressure is applied to the assembly during the heating step.

5. A method of manufacturing portions of magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: heating the two circuit parts, cooling the two circuit parts, placing spacing members having a thickness equal to the desired gap length at opposite ends of the first polished gap surface of one circuit part, placing a corresponding polished gap surface of a second circuit part on said spacing members in confronting relationship with said first surface thereby forming a gap between said surfaces, placing a quantity of nonmagnetic material adjacent to the gap, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gap by capillary action, and bonds the circuit parts together.

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6. A method of manufacturing portions of magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: placing spacing members having a thickness equal to the desired gap length at opposite ends of at least two polished gap surfaces of one circuit part, placing the corresponding polished gap surfaces of a second circuit part on said spacing members in confronting relationship with the gap surfaces of said one circuit part thereby forming gaps between said surfaces, placing a quantity of nonmagnetic material adjacent to the gaps, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gaps by capillary action, and bonds the circuit parts together, cooling the assembly, and then cutting the assembly along mutually perpendicular axes to form a plurality of head portions.

* * *

8. A method according to claim 6, wherein said nonmagnetic material is glass.

9. A method according to claim 6, wherein said nonmagnetic material is enamel.

10. A method of manufacturing portions of magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having confronting gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: placing a polished gap surface of one circuit part in confronting relationship with a corresponding polished gap surface of a second circuit part, said surfaces being separated by a gap equal to the desired gap length, placing a quantity of nonmagnetic material adjacent to the gap, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gap by capillary action, and bonds

the circuit parts together.

11. A method according to claim 10, wherein said nonmagnetic material is glass.

* * *

14. A method of manufacturing portions of magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having confronting gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: heating the circuit parts, cooling the circuit parts, placing a polished gap surface of one circuit part in confronting relationship with a corresponding polished gap surface of another circuit part, said surfaces being separated by a gap equal to the desired gap length, placing a quantity of nonmagnetic material adjacent to the gap, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gap by capillary action, and bonds the circuit parts together.

15. A method of manufacturing portions of magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having confronting gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: thermally etching the gap surfaces of the two circuit parts, placing a polished gap surface of one circuit part in confronting relationship with a corresponding polished gap surface of another circuit part, said surfaces being separated by a gap equal to the desired gap length, placing a quantity of nonmagnetic material adjacent to the gap, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gap by capillary action, and bonds the circuit parts together.

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6 The formula for determining the extent of capillary flow is:

$$h = \frac{2T \cos \alpha}{r.p}$$

where T = surface tension; $\alpha$ = wetting angle; r = 1/2 the width of the channel; and p = the density of the liquid.

7 In addition, plaintiff introduced two patents, cited by neither the patent examiner nor the defendants, concerning methods of manufacturing ferrite recording heads. Patent No. 3,217,305 to Hanson, issued November 19, 1965 on an application filed July 19, 1962, discloses a slight variation of the sandwich process consisting of grooving the ferrite faces. Patent No. 3,188,400 to Vilensky, issued June 18, 1965 on an application filed January 9, 1961, discloses a different manufacturing method. It teaches the coating of the ferrite faces with a glass and ferrite compound and, then, heating to fuse the two separate pieces. Including plaintiff's cited prior art, there are in fact 6 different patents in the trial record concerning ferrite head manufacture prior to the Peloschek patent.

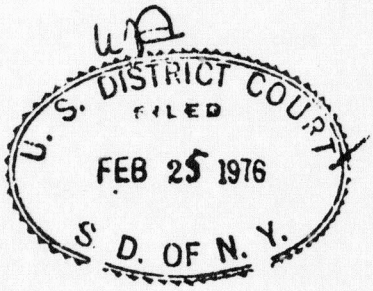
8 The symbol u" as used in the table stands for micro-inches.

9 The shims are deposited on the I-bar ferrite piece.

JUDGMENT APPEALED FROM.

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

| | | |
|---|---|---|
| U. S. PHILIPS CORP., Plaintiff, | : | |
| v. | : | CIVIL ACTION NO. |
| NATIONAL MICRONETICS INC., ET AL., Defendants, | : | 71 CIV 921 |
| v. | : | (RW) |
| NORTH AMERICAN PHILIPS CORPORATION, and N.V. PHILIPS GLOEILAMPENFABRIEKEN, Counter-Defendants. | : | |




JUDGMENT

This action having come on for trial before the Court, Hon. Robert J. Ward presiding, and the issues of patent infringement and patent validity having been duly tried, and an Opinion having been duly rendered,

It is Ordered and Adjudged that:

1. This Court has jurisdiction over plaintiff and defendants and the subject matter of the ~~complaint~~ pleadings.

2. Plaintiff, U. S. Philips Corp. is the owner of U. S. Letters Patent No. 3,246,383, issued on April 19, 1966, in the names of H. P. Peloschek and M.H. M. Vrolijks; and of U. S. Letters Patent No. 3,024,318, issued March 6, 1962, in the names

JUDGMENT APPEALED FROM

of S. Duinker and J. Bos, and of the right to recover for infringement thereof.

2. Said Duinker et al patent No. 3,024,318 is invalid and the complaint is dismissed as to it; said patent, ~~but~~ if valid, would be infringed by glass-bonded cores made or sold by defendant, National Micronetics, Inc., which cores use glass materials designated by Nos. 2107 and 2109 and illustrated by Micronetics part Nos. 35058 and 30239; but is not infringed by glass-bonded cores made or sold by defendant National Mictonetics, Inc. which use glass materials designated by Nos. 1303, 1201, 2205, or 2104, illustrated by Micronetics part Nos. 30152, 30331, 30134, 30245, 30156, 30005, 30037, 30085 and 30064.

4. Claims 1-6, 8-11, 14 and 15 of said Peloschek et al patent No. 3,246,383 are valid. Claims 1-4, 6 and 8-11 of said Peloschek et al Patent No. 3,246,383 are infringed by the process used by defendant National Micronetics, Inc. to manufacture its glass-bonded cores: Claims 5, 14 and 15 are not infringed.

5. Defendant Ned W. Buoymaster did not infringe or induce infringement of either of plaintiff's said patents, and the complaint is dismissed as to him.

6. The stay heretofore Ordered as to defendants' counterclaims is vacated and the parties are directed to proceed to an adjudication of the counterclaims.

7. Plaintiff's demand for an injunction and damages by reason of defendant National Micronetics, Inc. infringement of said Peloschek et al patent is deferred pending a determination of defendant's Second Counterclaim asserting violation of the anti-trust laws by plaintiff U. S. Philips Corp. in concert with

JUDGMENT APPEALED FROM

counter-defendants North American Philips Corporation and N.V. Philips Gloeilampenfabrieken by reason of patent misuse; the enforceability of the patents in suit are dependent upon and shall await the outcome of the trial of the aforesaid counterclaim.

8. There having been a split decision on the adjudication of the patent issues, no costs are awarded to either party.

9. Paragraphs 1-5 herein above constitute a final judgment of this Court pursuant to Rule 54(b), Fed.R.Civ.P. as to the patent issues. The Court hereby expressly determines that there is no just reason for delay and expressly directs the entry of judgment.

Robert J. Ward

Robert J. Ward, U.S.D.J.

Dated: New York, New York
February, 24, 1976

JUDGMENT ENTERED: - 2/25/76

Raymond F. Burghardt
CLERK

EXCERPTS FROM TRANSCRIPT.



jhlt 8 Kornei-direct

DIRECT EXAMINATION

BY MR. RELSON:

Q Mr. Kornei, would you state your residence?

A I live in Carmel, California.

Q What is your occupation?

A I am retired.

Q What was your occupation previous to your retirement?

A I was a research and development engineer.

Q Would you briefly outline for the Court your technical training and your technical experience?

A Well, very briefly, I was born in Vienna. I went to school there, and later on in Berlin, and I received advanced degrees both from the Institutes of Technology in Vienna and in Berlin.

Q About when was that?

A In Vienna it was 1923, I believe, and in Berlin it was about six or seven years later.

Q Would you just outline very briefly your professional experience?

MR. CALIMAFDE: Your Honor, I have a professional biography of Otto Kornei, which appears to be Plaintiff's Exhibit 130-1, which appears to be a biographical sketch of the witness, and I would have no objection to this being

offered.

It may save the time of the Court if this was simply offered, rather than have the witness delineate his background.

THE COURT: I would be willing. I think I can read it and pretty much appraise the situation.

Is that agreeable to you, counsel?

MR. RELSON: Certainly, your Honor. I think that in some respects we might want to supplement this biography.

THE COURT: Anything that is not there already. But let me take the exhibit and look at it.

MR. RELSON: In addition, we have in book form as Exhibit 131, certain of the papers concerning Mr. Kornei including his certificate of election as a fellow by the Institute of Electrical and Electronic Engineers and the write-up on that and a set of papers and a set of his patents.

THE COURT: Very well . Apparently he worked on sound motion pictures early on.

Is that right, Mr. Kornei?

THE WITNESS: Yes, your Honor. That was in the beginning of my career.

THE COURT: And you worked on magnetic recording and phonographic recording at Brush Development Corporation,

is that right?

THE WITNESS: That's correct, your Honor.

THE COURT: And you were at IBM from 1956 to 1958 working on digital magnetic recordings, is that right?

THE WITNESS: That's correct.

MR. RELSON: I believe that was 1968, your Honor.

THE COURT: 1956-1968?

MR. RELSON: Correct.

THE COURT: I am not prescient. I am merely looking at the exhibits, so that I know that I have covered it all. I note his publications.

I gather he is offered as an expert, is that correct?

MR. RELSON: That's right, your Honor.

THE COURT: There is no objection to his being considered an expert --

MR. CALIMAFDE: No, sir.

THE COURT: -- and the Court listening to his opinions we asked for, is that right, counsel?

MR. CALIMAFDE: Yes, sir.

THE COURT: Let me just finish the next exhibit, 131, which I will look at. Is that also offered and received?

MR. RELSON: That is offered, your Honor.

THE COURT: No objection?

MR. CALIMAFDE: I'm not sure I know what 131 is.

THE COURT: Papers documenting the expertise of Mr. Kornei.

MR. CALIMAFDE: No objection.

(Plaintiff's Exhibits 130 and 131 received in evidence.)

THE COURT: I have had an opportunity to look at the exhibits. As I say, I will consider this witness to be an expert. You may inquire of him as you would any expert.

BY MR. RELSON:

Q Mr. Kornei, what is the field of technology or art with respect to which the present patents are concerned?

A It is the field of magnetic recording.

Q Is that the field in which you have devoted most of your active career?

A A very substantial part of my career, that's correct.

Q I want to bring out, Mr. Kornei, the degree of your familiarity with other workers in this field. Would you discuss that and describe to the Court, particularly with respect to your knowledge and awareness of the level of ordinary skill in this art.

A Well, in the course of my career, or more specifically, of my experience in the field of magnetic recording, which started in Europe and continued in this country, I have had occasion of meeting a large number of people in the same field, again, I must say, both in Europe and in this country.

These occasions were either professional meetings or contacts through the organizations with which I was working at the particular time.

Q Did you yourself supervise the work of other people?

A Yes, I did.

Q Can you give us a general idea of what size groups were supervised by you?

A This varied, of course, considerably in the course of the years, but it may have ranged from just a few people up to let's say about twenty people.

Q Have you personally engaged in the design of magnetic recording devices?

A Yes, I did.

Q Have you personally engaged in the development of magnetic recording devices?

A I did.

Q Have you personally engaged in the production

or manufactur of magnetic recording devices?

A I was not directly involved with production, but I advised and supervised production.

Q Did the magnetic recording devices with which you were thus concerned include magnetic recording heads?

A Yes, this is correct.

THE COURT: The head, as I understand it, is the portion of the device which is probably the most important single portion of the device, is that correct?

THE WITNESS: Yes, this is partially correct.

THE COURT: Partially correct?

THE WITNESS: May I elaborate?

THE COURT: Yes, please do.

THE WITNESS: Magnetic recording as such is -- maybe I should say this is an introduction -- is the oldest art of non-mechanical recording of information, in contrast, for example, to phonograph recording or other mechanical forms of recording.

In order to -- it was invented at the beginning of the centry, but remained dormant, almost dormant, at least from an economic viewpoint, for the next almost forty years, and only in the '30s, and especially during the Second World War, it attained rather substantial military and commercial significance.

From this time on it has taken an almost meteoric rise up.

Now, in order -- to come back to your question -- in order to practice magnetic recording you do need, very basically and essentially speaking, two component parts.

One is the recording medium and the other one is the recording heard.

MR.RELSON: Excuse me, your Honor. You might find it helpful to refer to Exhibit 132, which I offer for identification.

(Plaintiff's Exhibit 132 marked for identification.)

THE COURT: Is there any objection to its being received, Mr. Calimafde?

MR. CALIMAFDE: No objection.

THE COURT: Received.

(Plaintiff's Exhbit 132 received in evidence.)

Q Mr. Kornei, would you continue your discussion, and where helpful, would you refer to Exhibit 132?

A Yes. It is through the cooperation of these two basic devices, magnetic recording medium and magnetic heads, that magnetic recording as such is accomplished.

Now, in the lower portion of this figure 1 --

THE COURT: Just so I am clear, the medium is what the recording is put onto in the usual course, tape or

something similar?

THE WITNESS: It could be tape, it could be the surface -- a magnetizable surface of a drum or of a disc.

Q Or of a cord, possibly?

A Or of a cord.

THE COURT: To just draw a parallel, the magnetic head would be like a pen or pencil and the recording medium would be like paper?

THE WITNESS: Very correct.

Q Is there an analogy also, Mr. Kornei, between this magnetic recording and a phonograph recording system?

A Well, in a phonograph recording system you alter the physical condition of the recording medium, of the record disc, by cutting out in a controlled manner some material by means of a cutting stylus.

Now, the analogous situation exists here, instead of cutting out you impress a controlled magnetization by means of the recording head upon the recording medium. This is done mechanically, and this is what I tried to point out in the beginning.

Shall I continue?

Q Please do.

A The way in which this is done is schematically shown in figure 1. The ring-shaped structure in the center of this figure depicts in a schematic way a recording head. It has --

Q Excuse me, is that what is labeled in the diagram "magnetic head" or "ring head"?

A Yes. It is called ring head because it has a ring shape.

I should point out, however, that the ring shape need not necessarily be round and angular as it is shown here. Ring refers to the fact it is essentially a closed structure. That is with one minor exception.

THE COURT: Could I have the device again, please? I want to have that in front of me while the witness is talking.

A The place in which the ring shape or the closed magnetic structure has a break which is shown in the lower portion of the structure --

THE COURT: Which is labeled "gap"?

THE WITNESS: Yes.

A (Continuing) It is a gap in the sense of magnetization. It need not necessarily be a physical gap, but it is a break in the magnetic circuit, the otherwise closed

magnetic circuit.

The head also carries a winding which can be supplied with electric current according to the information which we want to record. It could be voice or music or digital data or most anything else, video information, what have you.

The way this is practiced then is shown also in a schematic way on the upper part of this figure way over on the left side where you see a rectangle marked "Data source." Again, this could be a microphone or any other source of information.

Q What form is that data physically? Is it electrical signals?

A The data must leave the data source in electrical form otherwise it is not useable for magnetic --

THE COURT: The data source emits electrical impulses?

THE WITNESS: That is right. The amplifier shown is a triangle and from the triangle you go to a switch which can switch the electrical impulses into the winding of the head, thereby supplying the head with the electrical image or the electrical equivalent of the information which you want to record.

THE COURT: An electrified head will trace the

magnetic pattern on the recording medium. Is that basically what happens?

THE WITNESS: That is what is basically happening.

Q Mr. Kornei, doesthat mean that on the recording medium, there is a magnetic replica of the original signals?

A It is a replica, that is correct.

THE COURT: A tracing, really?

THE WITNESS: Well, I believe I failed to mention one thing.

The recording medium which is of vital importance, the recording medium is moving passed the head at a certain constant speed. In this way, the individual data increments which follow in time into the winding of the head are then recorded following in space on the surface of the recording medium. It is again exactly the equivalent to cutting with a record cutter into the groove of a phonograph.

THE COURT: Or to use another equivalent, I suppose, to expose movie film, so as the film is running, the exposure through the lenses causes an image and here, instead of there being a visual image, there is an audible image?

THE WITNESS: It is an invisible image.

THE COURT: You could hear it.

MR. RELSON: With appropriate apparatus. You hear

it if you are listening for it -- I should not tell you this.

THE COURT: I think this is basic matter which I think within limits common experience may possibly dictate the answer.

In his background anyway and I didn't mean to interrupt.

Q Mr. Kornei, you might describe briefly the counterpart situation during picking up or reproducing or what is sometimes called reading from the magnetic medium.

A After the magnetic impulses have been recorded on the recording medium, obviously we want to reproduce them in some useful manner. In order to do this, the recording medium is passed by the gap of the magnetic head again and the minute, incremental magnets which then exist in the recoding medium will pass by the gap of the head, will induce a small magnetic flux in the closed circuit of the head and furthermore, induce small electrical impulses of voltages in the winding of the head which conversely then can be used in the reading process.

This is also shown in this picture, the same switch which permitted before the recording connection, can conversely connect the winding of the head to the playback

or read-out amplifier, then finally to what is called in a general way here, data utilization which could be in the simplest way, a loud speaker.

Q Would you explain figure 2 in general terms?

A Figure 2 is an enlarged view of the gap area of the ring head. It does show again, in a schematic way, the configuration of the magnetic flux lines traversing the gap and partially leaking out, leaking away from the gap and traversing the upper layer of the recording medium.

These are the curved lines at the bottom of the gap.

Q Are these flux lines or field lines, what permit the interaction between the core of the head and the magnetic medium?

A Yes.

Q I have used the term "core." Will you explain to the Court what that terms means within the art and how it distingues from the term "head"?

A One important part of the head is its magnetic core which is again, referring to figure 1, the almost closed magnetic circuit which carries a gap on one side and also carries a winding.

The purpose of the core is to carry the magnetic flux required in writing, or in the recording process and

conversely then, in the read-out process in the production of the signals. This core can have various configurations.

As I said before, it need not necessarily be angular, but that it be a close core.

MR. RELSON: I offer Plaintiff's Exhibit 134.

THE COURT: Any objection?

MR. CALIMAFDE: No objection.

(Plaintiff's Exhibit 134 received in evidence.)

THE COURT: What you have called before, I have seen what I would describe to you as an electromagnet. That is the part of the magnet about which the wire is wrapped.

THE WITNESS: Yes. The magnetic head can be considered a miniature electromagnet.

THE COURT: I gathered that from your prior statement.

Q You were mentioning that the core need not be round as shown in Exhibit 132. Would you elaborate on that and use Exhibit 134 as may be helpful?

A Figure 134 shows two possible forms of a core. The upper part is called a closed core, consisting of two magnetic portions, each one on the left and on the right. They happen to be symmetrical in this case. Each one pole piece or half-core. By putting the two together, we obtain

again, an essentially closed magnetic circuit. At the bottom we find the gap and at the top we have what we call back gap which really is not functionally required, but it is required usually for manufacturing reasons so that the whole structure can be manufactured from two pieces which are put together.

Q Does that facilitate placing the winding on the core?

A This facilitates placing the winding and it facilitates the manufacture of the pieces.

THE COURT: They could be made as a single piece without any change in result, I gather?

THE WITNESS: They could be made but there arise certain problems which I don't know whether I should go into.

Q Explain them to the Court.

THE COURT: I am not looking to probe deeply here. You can just give me the background.

THE WITNESS: Yes, it could be made of one piece.

Q The diagram of Exhibit 134 also has the term pole tips. Will you explain what that term signifies?

A Pole tips are the portions of the pole pieces which are immediately adjacent on either side of the gap

and you could consider the gap to be formed by being bound by the two confronting pole tips.

THE COURT: Again, without trying to interrupt too many times but so I can conceive this, this would appear to be similar to a horseshoe magnet.

Each end of the magnet is normally called a pole.

THE WITNESS: Right.

THE COURT: I gather this is similar, at least in concept, to a horseshoe magnet.

THE WITNESS: It is very similar, indeed. There is a physical difference, as we will find out in great detail later, but the gap required here, is very, very minute dimensions, but it is essentially a horseshoe magnet.

Q As a matter of terminology, would you explain what is meant by gap length, gap height and gap width, as shown on the diagram of Exhibit 134?

A The spacing between the two confronting faces of the pole tips, as it can be seen in figure A on this page is called gap length. This is sometimes in the beginning a confusing term. It is called length merely because its dimension is measured in the direction of the longitudinal motion of the recording medium.

Q On some early publications and patents, was that

occasionally called gap widths?

A Yes, and it leads to endless confusion.

Q Will you explain gap height and gap width?

A Gap height is the dimension measured in a vertical direction with respect to the recording medium and the gap width indicates really the thickness of the pole pieces and it does ultimately result in determining the width of the magnetized track on the recording medium or the track widths.

Q Is that sometimes called track-wide?

A Yes, as indicated in the figure.

(Continued on next page.)

Q Is that the dimension parallel to but transverse parallel to the recording medium but transverse to the direction of motion?

A Yes, this is correct.

THE COURT: The core sits on top of the track which moves laterally and the head which is part of the core is what traces the magnetic pattern on to the moving track.

THE WITNESS: Right, your Honor.

THE COURT: I think I roughly at least understand, so far.

Q Would you explain the Open-Core diagram on Exhibit 134?

A The Open-Core in the lower portion of this page consists again of two pole pieces. At the bottom between the two pole pieces and in a similar way again we have the gap, with its dimensions of gap lengths, width and height, but as one can see, the two pole pieces do not close at the top the way they closed in Figure A, but are left open.

In order to build an efficient and effective head, we have to close them in some way and to do this, there is shown in dash lines, the so-called back bar or keeper which is nothing but an additional piece of core

material which can be either clamped or cemented or otherwise fastened to the lower pole pieces, in this way completing the circuit again.

THE COURT: The material which is utilized for the back bar, is that identical material to the material utilized for the pole pieces?

THE WITNESS: Essentially the same.

THE COURT: The back bar you say is clamped on to the pole pieces?

THE WITNESS: Correct, your Honor.

THE COURT: What is used to clamp it on, some sort of an epoxy or glue or something else?

THE WITNESS: If it is glued on or cemented on, you could use an epoxy or almost any kind of cement.

I want to point out if it is cemented, one has to see to it there is as little separation between the two joining faces of the back bar and the rest of the structure because this would present a certain obstacle to the magnetic flux.

Q In this context, would you explain what is meant by potting?

A Potting has and can have various connotations. One form frequently used in conjunction with magnetic heads, it is the complete immersion of a magnetic head in a

suitable synthetic resin in order to hold individual pieces together and to protect them. So-called epoxy resins are frequently used for this purpose.

Q Would such a procedure be used to maintain a back bar in appropriate contact with the pole pieces?

A It could be used. It would not be an ideal solution, but it could be used.

Q Mr. Kornei, will you first explain what is meant by information density then discuss its importance in the magnetic recording art.

A In the recording of any kind of information, one would usually attempt to place the individual increments which form the information as closely together as possible, primarily for economic reasons. It is like writing in very small letters. You get more on one sheet of paper if you write with small letters for which you need a sharply pointed pencil corresponding to a small gap in a magnetic head.

The information density all in all comes about by feeding fairly high frequency into the winding of the head and passing the magnetic recording medium past the gap. As the frequency increases for a given speed of the recording medium, the consecutive impulses recorded on the medium will obviously become closer together.

Q Would you explain briefly the significance of frequency and the ranges of frequency that are used in magnetic recording for different purposes.

A The magnetic recording, as it is practiced for voice or music is a comparatively low frequency band or frequency range involved, which may not extent, let us say, roughly, about 20,000 cycles per second. In digital recording, these numbers do become very much higher and they have been growing in the course of the years with the advent of modern computers.

In today's computers, we are dealing with frequencies on the order of several hundred thousand cycles or parts per second up into mils of cycles or parts per second.

Q In video recording, what would the approximate range of frequencies be?

A Several mils of cycles or as we call it several megacycles.

Q You were discussing the factor of frequency in relation to high information density.

Would you continue that discussion?

A Yes. Maybe I could make this clearer.

Q Let me ask specifically. What effect does frequency have on attaining high information density?

A As I said before, for a given speed of the recording medium, a higher frequency will result in closer spacing of the individual magnetized spots or increments.

Q Has it been a goal of the industry to attain practical recording of higher frequencies?

A Yes, it has been.

Q How important has that been to the development of the computer industry?

A It has been of very great importance because higher bit density or information density permits you to use less of the recording medium and therefore permits the building of smaller equipment and more economical equipment.

Q Conversely, does that permit the processing of more information for equipment of essentially the same size?

A This is correct, yes.

Q What are the characteristics of a head which would be necessary for attaining high information densit?

A There are primarily two requirements. First of all, and this is almost obvious: In order to obtain very high bit density, you want to have a very sharp pencil to write with, which means you want to have a very short gap in the recording head which permits putting down and later on reading out very small megnetized spots.

Q You used the term "bit density" which is a new one.

Would you explain what you mean by that?

A In the parlance of the computer language, the term "bit" is used. Bit merely denotes one individual element of information.

Q You are explaining that one element of a head desirable for high information density was s hort gap. Will you proceed with your explanation?

A As the need for higher information density increased, the gaps in the head change. They became shorter and shorter. For today's requirements, to name possibly a representative figure, the dimensions of gaps in heads for computers may be on the order of 100 microinches or we can also call it one-tenth of a million.

In order to give an idea of the smallness of this figure, I would like to compare it with the thickness of an average sheet of paper. The usual 20-pound bond paper has a thickness of approximately 4 mils. If we are talking of 1/10 of a mil that would be 1/40 of the thickness of a sheet of paper. This conveys, I believe, an individual idea of the smallness of this gap.

Q Is it correct that one mil is 1/1000 of an inch?

A Yes.

Q A microinch is 1 millionth of an inch?

A Yes.

Q 1 mil would be 1000 microinches?

A This is correct.

MR. RELSON: Your Honor, there are a number of these units that may be referred to in the course of the trial and we have prepared a sheet, Exhibit 136 which indicates a number of the ones that may come up and their relationship.

I offer Exhibit 136.

MR. CALIMAFDE: I have no objection to 136 except for the last two, I suppose definitions, one part per mil and the one below that, ten parts per mil.

(Plaintiff's Exhibit 136 marked for identification)

THE COURT: Yes, I see it now.

MR. CALIMAFDE: The last two items on Exhibit 136. In our view, your Honor, they are inadequately expressed. A part per mil cannot be expressed as one times ten to the minus six, for example.

THE COURT: A mil is ten to the minus six.

MR. CALIMAFDE: Yes. One part per mil --

THE COURT: It should be one over ten --

* * *

of a magnetic head necessary for high information density or high bit density, as you expressed it.

THE COURT: You need a short gap.

THE WITNESS: You need a short gap.

THE COURT: What else do you need?

THE WITNESS: You need -- this is a purely geometric requirement, the short gap, but you need something else in a recording head in order to be able to record high frequencies or then in turn high density. You need a core which has low losses in the high frequency range.

Q Would you explain how losses are related to frequency?

A In any magnetic core or in any electromagnet which is supplied with an alternating current losses in the core will arise. These losses will manifest themselves simply by heating up of the core. Some of the energy which you put into this electromagnet will simply be lost in heat.

Q Do such losses result in lower efficiency?

A Such losses, of course, result in lower efficiency. These losses increase rapidly with frequency.

THE COURT: High frequencies within the normal course increase heat, increasing losses.

THE WITNESS: Right.

THE COURT: Therefore, you need a material which will retain the heat.

THE WITNESS: Well --

THE COURT: If not, just tell me. You need a material that will do what?

THE WITNESS: Not quite, your Honor. You need a material which will have no losses or have low losses to begin with.

THE COURT: How is that affected, by the type of material or its design?

THE WITNESS: By the type of material.

Q Has this problem of loss been a limiting factor on the frequencies that are usable in magnetic recording?

A Yes, it has been with magnetic recording ever since the beginning.

MR. CALIMAFDE: Your Honor, I have not objected to many of these questions because I too am interested in a development of information in the most expeditious way and in the most comprehensible style.

The questions oftentimes have been open-ended in terms of time. For example, that last question, has it been desirable to have high frequencies. Until what time;

* * *

What was at that time the type of magnetic recording head that had been developed for the purpose of as high a frequency as the art could tolerate?

A Right. The prevailing form of the cores used in magnetic heads up to let's say very roughly 1950 was a core which was made up of a stack of individual laminations or one could also call it of individual thin sheets which we packed together formed the final core. This --

Q Mr. Kornei --

THE COURT: I would like to have him finish.

THE WITNESS: This is a well known approach also used in power engineering to reduce core losses. Perhaps we do not have to go into how it was reduced, but instead of taking one solid block of a magnetic material we rather use a stack of individual sheets cemented together to make up the core of such a magnet. It is used, for instance, in transformers and in generators and in motors and so on.

THE COURT: And the purpose is to minimize the heat loss.

THE WITNESS: To minimize the losses, and one can generally say the thinner the individual laminations are the lower the losses will be.

MR. RELSON: I offer Plaintiff's Exhibit No.

* * *

head looking from the gap and this is another head.

THE COURT: And there is a line at each end, is that right, and one in the middle also?

THE WITNESS: The line of significance -- that means the actual gap -- is only the line within the stack of lamination. The rest is supporting means.

THE COURT: Thank you.

So that the more obvious line that I had seen previously was irrelevant to our consideration?

THE WITNESS: Is irrelevant, correct.

THE COURT: The line I should be looking at is in here in the stacked pieces, running this way, is that right?

THE WITNESS: Absolutely.

THE COURT: I see it and I thank you. That is the gap?

THE WITNESS: That is the gap.

THE COURT: Almost unobservable to the naked eye. Thank you.

BY MR. RELSON:

Q Mr. Kornei, what did the art do in an effort to increase the frequency range of heads of the laminated type?

A As the need for higher and higher frequency increase the industry, of course, attempted to use thinner and thinner laminations, because thinner laminations tend toward

decreasing the losses.

Q Was there a physical limit to that effort?

A But very soon, of course, a practical physical limit was found, on the order when the lamination came down to a thickness of about one-thousandths of an inch. Below this it became rather awkward and almost impossible to handle it. One found that such magnetic heads made of these thin laminations could still be used advantageously up to frequencies on the order of about one million cycles per second.

Q Is that also called a megacycle?

A One megacycle or one megahertz, if you want to be exact these days.

Q What has the art --

THE COURT: Wait a minute. Did you finish your answer?

THE WITNESS: I was just trying to continue.

Q Please continue.

A When this limit was reached the industry, of course, started looking for some other possible core material which would not show these high losses.

Q To what material was the industry's attention directed?

A It was fortunate just about that time a

relatively new material became available, which was called ferrite, or we should call the sintered ferrites.

Q Would you explain what is meant by sintering or a sintered material?

A Yes. Ferrites are non-metal like magnetic materials which are composed of a mixture of, broadly speaking, iron oxide and other metal-like oxides. These oxides can be mixed in powdered form and can then be compressed and heated at some suitable fairly high temperature, which process is called sintering.

Sintering the individual particles or grains, if you will, of this mixture, will fuse together and form one solid body, which, however, will always retain a granular structure because of the way in which it was made.

Q In what way were ferrites advantageous for use in magnetic recording heads?

A Inasmuch as the electrical conductivity of ferrites is very low, the loss in ferrite cores are also low.

I should have mentioned before that the primary cause of the loss in metallic, that means in conductive materials, is based on their conductivity, and the lower the conductivity, the lower the loss will be.

THE COURT: Lower heat loss?

* * *

A Absence of sharpness essentially gives rise to a crooked edge. Between the crooked edges, it is virtually impossible to generate a very short gap.

That means, the absence of sharpness will be tantamount to building a longer gap than you intended to build.

Q Will such a gap which has non-sharp edges function as though it were a longer gap?

A Yes, it would.

Q Would you refer for a moment to Exhibit 132, Mr. Kornei and ask you to explain to the Court the particular edge to which you are referring, and I think this diagram will help you to illustrate it?

A 132, the lower figure which shows edges in the illustration and these edges really bound on the left and the right side the dimension, that means the length of the gap. It is quite obvious you want to have these edges very well defined, very sharp and parallel in order to define a very short gap.

Q Are those the edges that are closest to the magnetizable medium?

A They are the edges closest to the recording medium.

Q Is the rest of the gap also significant

with respect to the attainment of additional results with short gaps? I am referring now to the remainder of the opening surfaces from the edge on up.

A The so-called depth or height, as it is called of the gap is a very important dimension. As I said before, this is a dimension of the opening pole piece faces away from the recording medium, vertically to the recording medium surface.

This dimension should be kept as small as possible in order to obtain high signals.

Q Is it important that the surfaces that are opened to one another and define the gap, is it important that they be smooth?

THE COURT: He said that I thought. Didn't you just tell us this?

THE WITNESS: I was primarily speaking of the edges but it is an inescapable conclusion from this that in order to generate very sharp edges, you must have very finely finished opening polished faces otherwise you cannot generate the sharp edges.

THE COURT: And they must retain their smoothness?

THE WITNESS: Yes.

Q Would chipping or grain pullout in the surfaces,

* * *

because I wasn't sure which you were referring to, and I think that Mr. Kornei may have the same difficulty. Would you rephrase the question for him.

Q Mr. Kornei, with respect to a chemical composition of the glass, how does that have an influence upon the factors of formation of bubbles or interaction between the glass and the ferrite?

A Well, the glass, for instance, as you increase the temperature, may decompose.

Q Is that influenced by the chemical composition?

A Yes, certainly. It could release dissolved gases in it, it could show an effect which is called crystalization of the glass. Glass at certain temperatures start to crystalize, it loses its glass-like texture.

THE COURT: Glass is contained or composed, I gather, of perhaps seven, eight or more elements, is it not?

THE WITNESS: Well, it is quite a number of elements involved, but in connection with what was discussed here it is important to keep in mind that glass even at room temperature physically speaking is considered a liquid. That means it does not have any ordering of the molecules in it. Once such ordering takes place, then it crystalizes, to the best of my knowledge, though I'm no glass expert. But this is what I learned.

* * *

Consequently, these spacings between head and surface have to be kept as small as at all possible. The idea situation is contact, but if you cannot afford contact, then you have to go to very small spacing.

THE COURT: And the aim is high resolution or quality?

THE WITNESS: Absolutely right.

Q Can you give a representative figure for the spacing that is used in practice?

A The spacing between the head and the recording medium surface may be on the order of, again, millionths of inch. Maybe 100 millionths of inch or 50 millionths of inch.

Q That would be 100 or 500 microinches?

A Yes.

Q Mr. Kornei, would you refer to Exhibit 132, which was a diagram you used in explaining some of the basic principals of magnetic recording.

Does that illustrate the spacing that you have just been testifying about?

A Yes.

Q Would you point that out for the Court, in both Figures 1 and 2?

A It is designated by head to surface spacing

* * *

examination of his witnesses whereas I think the crux of his case is right now and if that can be made most meaningful to the Court, it will aid all of us without imposing on me a cross examination --

THE COURT: May I suggest the last word be the one that remains in the ears of the hearer and you will have the last word. Perhaps you would be correct with a jury. I should think since I have to make a decision with findings and conclusions based on the entire record, you could in no way be prejudiced by this. To fragment your examination, will by my experience, only prolong it.

Application granted. Call your next witness.

MR. RELSON: Mr. Vrolijks.

M A T T H I J S V R O L I J K S , called as a witness, being first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. RELSON:

Q Mr. Vrolijks, where do you reside?

A I live in Waaler, Netherlands.

Q By whom are you employed?

A By N.V. Philips Eindhoven.

Q Would you state briefly your technical education?

A I finished an education which would be comparable with high school in 1947, with emphasis on mathematics, physics and chemistry, and then I started to work for Philips at the research laboratories.

Q Have you worked continuously for N.V. Philips since that time?

A I have worked for Philips since that time with an interruption of two years when I went into the Service and during my work for Philips, I continued to study in courses which were mainly organized by Philips.

Q Will you outline very briefly the various projects, in a very general way, in which you are engaged at N.V. Philips, beginning in 1947?

A Yes. I started in 1947 working at the research laboratories which are completely independent laboratory for general research, of course in the electronics direction but they are rather free to choose their subjects and I worked in the group of magnetic materials where we were doing investigations on ferrites.

In my rather junior position then, I worked together with physicists and chemists. I made the different materials, mixes and all the work to it until

* * *

A In this laboratory I continued to work on ferrites until 1960. In 1960 I started -- I was put on a specific project, ferrites for recording heads and in 1961 gradually the emphasis in my work was transferred from the development of technology for glass-bonded ferrite heads.

THE COURT: When was that?

THE WITNESS: In the course of 1961.

A (Continuing) I continued to work on that group of ferrite recording heads until 1966.

Q Were you in charge of the group?

A No, I was not. The last part of that period I was in charge of the mechanical process technology involved with these recording heads. Another man was responsible for the electrical design of the heads.

Q What happened in 1966?

A In 1966 I was transferred to the commercial department and I became responsible for the technical-commercial aspect of these ferrite recording heads.

Q How long did that continue?

A That continued until 1973 where in the course of this period I became product manager for these products, so also I became responsible for turnover, profit, et cetera.

Q Is turnover what we ordinarily call sales in

the United States?

A Yes. It is turnover to external customers.

THE COURT: The product for which you became product manager for was glass-bonded magnetic recording heads or other products as well.

THE WITNESS: This was my job, glass-bonded magnetic recording heads.

Q Are you the Matthijs Vrolijks who is referred to as a co-inventor of United States Patent 3246383?

A Yes, that is me.

Q And you are joint co-inventor is identified as Hans P. Peloschek. What was your relationship to Mr. Peloschek during your career at N.V. Philips?

A My relationship in the period of the invention, you mean?

THE COURT: Tell us about who he was. I think we ought to start with that.

Was he a fellow employee of yours at Philips?

THE WITNESS: He was my direct boss at the time of the invention.

THE COURT: Which was in 19 what?

THE WITNESS: 1961, 1962, but we worked very close together. Hierarchy was not so strong in our organization.

Q In the course of your work at N.V. Philips, did you become acquainted with the work of Mr. Duinker with respect to glass-bonded ferrite --

THE COURT: May I ask one question before you get to that.

Is Mr. Peloschek alive today?

THE WITNESS: Yes.

THE COURT: Is he still employed by the company or has he retired?

THE WITNESS: He is still employed by the company.

THE COURT: In the Netherlands?

THE WITNESS: Yes. He is about my age. Maybe two years older.

THE COURT: Thank you.

Q In the course of your work, did you become acquainted with the work being done by Mr. Duinker on glass-bonded ferrite recording heads?

A In the course of my work at the research labs, I became acquainted with it, in the course of 1960 when I got the responsibility to develop completely the materials for these glass-bonding heads.

THE COURT: Let's go back. When did you first become acquainted with the Duinker patent?

THE WITNESS: With the patent as such, I was not really acquainted in that period.

Q What about its subject matter?

A In the period when I started to work on the glass-bonding technology, which was in the course of the beginning of 1961, then I was aware of the work they had done. I had seen internal reports and notes on this matter.

Q Did you undertake to acquaint yourself with the prior technology on glass-bonded ferrite cores when you entered that project?

A Yes. I had to understand the work done by the people at the research labs which we normally refer to as Duinker's group, and the people in our laboratory who had already started on this project before I entered into it.

Q At what stage of development, in the direction of leading to commercial production, had the Duinker project gotten at the time you began your work on glass-bonded cores?

MR. CALIMAFDE: May I hear that question.

(Record read)

MR. CALIMAFDE: Objection to it on the ground it is leading and no foundation laid for the Duinker project

ever getting into production.

THE COURT: Sustained. Leading. That is the basis for my sustaining the objection.

Q Would you describe what the status of the Duinker project was as you learned it at the time you became affiliated with the glass-bonded core project?

A Yes.

Our laboratory was trying to produce on a small scale magnetic heads according to the Duinker process. This method which has been described this morning as using glass foil is the means to produce the non-magnetic gap between the two magnetic materials and we had quite a lot of problems in realizing some production with reasonable yield.

Q Will you explain what is meant by "yield"?

A Yield is the final resulting good heads which you obtain from starting, but you can express it as a percentage, which might be the most useful thing.

THE COURT: In other words, you wanted to have more acceptable heads than those which were not acceptable?

THE WITNESS: Yes, you would like to have it.

THE COURT: You would like to improve the quality of your production?

THE WITNESS: Your Honor, the user generally gives specifications. He says "I want a magnetic head with this track" which had a certain specified gap length, and with good service quality and on that basis you could further continue and construct complete heads including coiles, etc., but the basic part had to be without mechanical failures and had to meet the mechanical requirements and our major problem was to obtain with the Duinker process magnetic heads with the required gap length tolerance.

Q Would you explain what is meant by tolerance in this context?

A In this context, we had a target specification of the heads we should make, a gap length between three and four micrometers as one tolerance band and the other between five and six or six and seven, but at least tolerance bands with widths of thirty-nine microinches, forty micro inches.

Q Is a micrometer the same a micron?

A Yes.

Q That would be about forty micro inches?

A That is about forty micro inches.

So, our major problem was to obtain reasonable yields and this was due to a number of reasons. The major

reason --

Q Before you get into that, let me ask you whether you or your group actually performed the process which you have called the Duinker process.

Do you do the glass bonding in your own group?

A We did it in our own group, yes.

Q We are now talking, I gather, about 1961?

A We are talking about 1960, early 1960 or the course of 1961.

THE COURT: As I understand it, the Duinker patent was filed in the Netherlands sometime in 1955 or 1956.

MR. RELSON: That was in the United States.

THE COURT: October 4, 1955.

In the period from 1955 to 1961 when you began working relative to production, was the Duinker patent being used by Philips on a production basis or was it still in the development stage?

THE WITNESS: It was still in the development stage.

Q Had it been modified or improved in the interim between 1955 and 1960?

MR. CALIMAFDE: This is leading.

THE COURT: Yes, it is. I suppose I can lead, but you shouldn't.

Q Will you explain, Mr. Vrolijks, the exact process that was being employed in the development of glass-bonded cores at the time that you entered the project?

A Yes.

Of course you must realize that as we said, it was still in an experimental and developmental stage.

THE COURT: We are talking about 1961 now?

THE WITNESS: 1960, 1961.

A (Continuing) In an experimental and development stage, which meant we did not have a completely fixed procedure with temperatures fixed, pressures fixed, etc. We were trying to optimize the procedure. The methods we were using was to produce glass foils -- the method I will describe later -- these glass foils were placed on the polished ferrite surfaces with and without the use of shims as stops in the final squeezing or pressing stage to produce the magnetic heads, the core assembly.

THE COURT: Let me hear that answer again.

(Answer read.)

MR. RELSON: Your Honor, we prepared a rough simulation of some of these on an enlarged scale that might help in understanding and for purposes of demonstration, I will just offer for identification Exhibits 171A, B, C and D. There is a multiplicity of some of these.

(Plaintiff's Exhibits 171A,171B, 171C and 171D were marked for identification.)

Q Mr. Vrolijks, first let us focus on one specific process.

You mentioned without shims. Considering that process only, what was the general shape of the ferrite pieces that were used in the glass bonding process?

A The general shape was of the form as you have there, the two slightly different parts, the channel shaped--

Q About what size were the actual pieces?

A We work generally with pieces which had the length of about twenty-five to thirty milimeters or 1 to 1.2 inches and a width of the order of 15 milimeters, but the width I don't recall exactly anymore. That is .6 of an inch.

Q Roughly five-eighths of an inch in fractions.

If you would consider this Exhibit 171A to be a simulation of one of the ferrite pieces and consider Exhibit 171B to be a simulation of the other and also consider the pieces marked 171C as a simulation of the glass foil pieces to which you referred, would you, by manipulating these, illustrate for the Court the process that was followed in the case of no shims?

A In the case of no shims, the glass foils were

placed on top of the two surfaces of this "U"-shaped model, and I would like to point out that it now seems a very simple thing to do because these parts are much better than the glass foils we could produce at the time. We had a great problem in producing these and they were rather curve-shaped parts often.

Q How were they produced?

A They were produced by blowing out the heated end of a glass tube, then you get such a sausage form balloon and out of this we cut out parts for our heads.

Q How could you tell what thickness the foil was?

A We measured with a micrometer type measurement. A gauge clock, I think it is called.

Q You physicall measured the thickness?

A We physically measured the thickness and there were people who had experience in looking into these matters under mono chromatic light and the interference helped to find out what area was rather equal in thickness.

Q What did you do with the areas that were of equal thickness?

A There we cut out with different means, among other razor blades, to put on the polished ferrite surfaces. After doing this, the other part was simply placed upon it and this whole assembly was placed in a furnace. A pressure

was put on, or means of a pressure were put on so we started with a rather low weight and during heating in the area where the glass softened, there the weight was increased to produce, to make the glass somewhat fluid -- I don't think that is the right word.

THE COURT: Soften?

THE WITNESS: It softens and then the bonding in effect took place and afterwards the whole assembly was cooled down and the weight had to be taken off and that was the end of the essential procedure.

MR. CALIMAFDE: Your Honor, in order that the record be made clear, perhaps the witness ought to identify the process he just described.

Was that the Duinker process that you just described to the Court?

THE WITNESS: To my opinion, that was the Duinker process. That was the process which was used in our development laboratory on the basis of work previously done by Duinker in the research laboratory.

THE COURT: Let me just clarify it one step further, following the line counsel has adopted.

As you were working in the laboratory, what if any written material did you have to refer to?

THE WITNESS: We had internal reports from the

research labs which were used, but which helped us to become familiar and informed about the work which had been done before.

THE COURT: Were any of those reports by Duinker?

THE WITNESS: They were by Duinker and his people and I do not recall whether they were specific reports from him.

THE COURT: Duinker had worked for the company?

THE WITNESS: Yes.

THE COURT: Was he working for the company in 1960, 1961?

THE WITNESS: In 1960 he was still working for the company. Then I have met him once or twice in this work, but later he left. I don't know when.

THE COURT: Had you taken over from Duinker and his people some work books, is that it?

THE WITNESS: No.

THE COURT: I would just like to clarify in my mind:

Working in your laboratory, were you using any materials which were reduced to writing as you worked along on your experiments, and if so, what?

THE WITNESS: As I have said, there were internal reports from the people in that group and that we used and if

I may clarify, in addition we had regular meetings with some people of his group who had done the work and when we had problems, we would say "What do you think of this and this," so we tried to work together. But they were in a completely different atmosphere, of course, of research people.

THE COURT: Finally, did you during the period of your experimentation work with any outside material, that is, material produced outside of the Philips organization?

THE WITNESS: No.

THE COURT: Thank you.

Q Would you state whether or not in the course of this Duinker sandwich process that you have been referring to, whether or not added glass was inserted within the closed loop formed by the ferrite pieces?

A I do not recall that.

Q Would you state whether or not there were difficulties or disadvantages with respect to this process that you have just described?

A Yes. I explained the large disadvantage of this method was the use of glass foils and we had no good method to produce these. So it was more on a trial and error basis that we could go on.

Further, in this method the final thickness of the gap was determined by the combination of time, pressure and temperature, and this together with the difficulty in obtaining good glass foils made it practically impossible to predict which gap length you would attain, and we got very low yields.

THE COURT: What were your variables now, time, pressure and temperature?

THE WITNESS: Time, pressure and temperature, and that caused the variations in gap length.

In addition, the non-flatness of the glass foils we started with caused what we call an air bubble problem. There were quite some gaps which had large voids and a series of small bubbles.

Q Was the existence of such voids or bubbles a disadvantage?

A Yes, it was a disadvantage in the later process

of managing and polishing the ferrite head surface for the ferrite and the glass then easily crumbled away if the glass did not support the ferrite edge.

Further of course in a later usage of the magnetic heads in contact with a recording medium it would be starting points for wear, these voids.

Q Would you state whether or not the yield attained was affected by the thickness of the glass foil that you attained?

A Yes. The attained thickness of the glass foil, of the final gap, was determined one side by the glass foil, so there a large variation in glass foil causes a large variation in attained final gap length.

Q Did you or did you not experience a large variation in glass foil thickness?

A We were forced to experience for we could not obtain glass foil with narrow tolerances. So we tried a lot and then we therefore also used rather often, the other method described by Duinker, using a combination of glass foil and shims as a means of stops.

Q Would you explain that method by itself, and if possible, simulate that method with the model in front of you.

A To do that I should need a pair of scissors.

Here we have four stops which had required -- had

a thickness equal to the required gap length. These were placed at the ends of the bar and then we placed inbetween, so somewhat smaller, glass foils of a thickness slightly above the required thickness.

I will simulate it on your side, your Honor. On that side the situation is correct. And again the same upper part was placed on this assembly.

Q In your simulation the transparent strip overlies one of the white pieces that you called a shim. Was that the case in the actual process?

A No, no. No, no. I explained clearly, I hope, that only this side now represents, the side of the Judge, represents reality. So here we used glass foils which were shorter.

Q Shorter than in the first process?

A Shorter than in the first process, so that they did not come on top of the shims.

THE COURT: With a shim at each end of the glass foil?

THE WITNESS: Yes. So in this case four shims.

THE COURT: Four shims for the four ends?

THE WITNESS: Yes.

Q Would you go through the following steps of the process in simulation and explain them as you do.

A So this shim or stop method was further processed in the same -- essentially in the same way.

The assembly was heated to a temperature where the glass started to flow, pressure was applied to squeeze the glass in this case down to the thickness of the stops.

The assembly was cooled down, pressure was released, and the obtained part could be machined, these surfaces could be machined and polished to produce magnetic heads.

Q When the two --

A Or parts for magnetic heads.

THE COURT: Would you indicate which surfaces were machined or polished from the model that you have in front of you.

THE WITNESS: I would like to say if you make magnetic heads in this method, as we had quite some reject, we always started to see whether we had produced a glass gap within the specifications to prevent a lot of work carrying out just to throw the thing away later.

So we started to polish only these two sides, measured the gap length, the obtained gap length, under a microscope, and then if the gap length was within the specifications we proceeded to machine further this bar, to cut this into two parts, and proceed to make the heads.

You want me to go into the details further?

THE COURT: No, not at this time. I will leave that to counsel to develop as he sees fit. I don't want to interrupt.

MR. RELSON: Your Honor, was that a full response to your question?

THE COURT: Yes, I think it was sufficient. I understood from the witness' response, gentlemen, that the polishing took place along what I will call each side of the model.

Is that correct?

THE WITNESS: That's correct, yes.

THE COURT: That was really what I wanted to know.

Q Was there a prior polishing of the ferrite before the pieces were put together in the sandwich?

A Yes.

Q Would you explain that to the Court, with the aid of the model.

A We started considering this model as being there, so I did not explain how we made these parts, but these parts are made from solid ferrite material.

THE COURT: And the ferrite was polished here, here, here and here, indicating the four edges?

THE WITNESS: That's right.

THE COURT: I understand that, yes. Then it was on top of the polished ferrite that you placed the glass foil?

THE WITNESS: Yes, your Honor.

THE COURT: And then with the glass foil between two polished ferrite surfaces, you pressed together?

THE WITNESS: Yes.

THE COURT: That hopefully ultimately would create a bond and along the sides which had not been polished previously once the bond was created, you then polished the sides, is that the process?

THE WITNESS: That is the process, and that was done primarily to see what we had made, the gap length we had made.

THE COURT: Off the record.

(Discussion off the record.)

THE COURT: The gap length, as I understand it, would be the area between the two faces, where I have now placed my finger?

THE WITNESS: That's right.

THE COURT: That is the gap length, so to speak?

THE WITNESS: That's right.

THE COURT: Thank you.

Q Is there a name used to designate the sandwich combination after it has been bonded? What is it called?

A We call it broodje.

THE COURT: Which is sandwich?

THE WITNESS: Yes, sir.

Q Have you heard the term bonded-bar used in this context?

A Yes.

Q Is that another name for this sandwich?

A Yes.

Q You explained that the bonded-bar, if I may use that term, after being bonded was polished and inspected as to gap length and then was cut longitudinally?

A Yes.

Q How were the core pieces fabricated thereafter?

A After we had cut this bonded bar into two halves there were different methods, depending on the ultimate head which was required. If there were required simple individual pole pieces such a half bar, half broodje, could be sliced in individual parts.

There was another method where we produced multi-track heads, so a number of tracks parallel to record on tape, parallel different information. For instance, a stereo head, you have two tracks. Then we sliced the parts --

slotted the parts only partly, inserted separation between the tracks, and then machined the front surface, thus obtaining individually separated tracks which were nevertheless bonded together with all the gaps in one line.

THE WITNESS: Is that clear, your Honor?

THE COURT: I think I understand what you said.

THE WITNESS: I could make a sketch, but it would take some time.

THE COURT: I would suggest this:

If you are close to finishing a particular series of questions, counsel, since I have people here on an order to show cause, which apparently they intended to present to me at a quarter to 1, we will stop. If you want to do a couple of questions and then pick up again this afternoon, I will let you do that.

MR. RELSON: I think it is just as well to terminate now and pick up this afternoon.

THE COURT: Let me suggest that we adjourn now. As I say, I have counsel here on an order to show cause. I will ask you to be back at 2 p.m. I indicated to you earlier that there are two criminal matters which are on for sentence at that time. I would be very surprised if either or both of the defendants appear, but I could be in error. So you may have to wait a few minutes.

I would ask, since it is now a quarter of 1, that you gentlemen return at 2.

(Luncheon recess.)

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AFTERNOON SESSION

2:45 P.M.

THE COURT: You may proceed, Mr. Relson.

MATTHIJS VROLIJKS, resumed.

DIRECT EXAMINATION CONTINUED

BY MR. RELSON:

Q Mr. Vrolijks, before the recess you had been describing for the Court two processes which were characterized as Duinker processes or sandwich processes, one of which you will recall had no shims and the other had shims as stops, I believe you said.

A Yes, that is what I said.

Q I want to refer you to the first of those, the ones without the shims for the time being.

Can you tell us whether or not cores made by that process were satisfactory cores?

A With that process we had succeeded in making satisfactory cores but only in very small quantities. We had extremely low yields due to the problems in this process. It was not really -- it did not work on, say, industrial scale. The problems we had were the following:

First, we had quite some rejects due to trapped air or air bubbles in the glass gaps. I think

I said that before.

Then another serious problem we had was that with this method you had to apply quite high pressure and doing this, and the variation caused by the variation in temperature -- I would like to back off and start this sentence again, please.

In that method, the final thickness of the glass gap was determined not only by the glass foil where we started from, but also by the influence of temperature and time and pressure. So, this process was very critical and this was the reason we had a lot of rejects due to variation in gap length.

Q Where a reject was due to a variation in gap length, would you state whether or not the core was still a satisfactory core for use.

A Yes. Probably I have to go back to the requirements for a specific type of head. It was needed to have a specific gap length or gap length tolerance band and the heads should have this gap length.

In having a large variation, we had only a small part of heads which were usable.

In principle, another core would be usable for another application, or for another specification, but of course there were only certain tolerance bands

required for different applications.

Q You spoke of an affect of high pressure. What was that effect on rejects and what type of rejects did high pressure cause, if any?

A The high pressure gave us the problem that we had obtained cracked ferrite parts after the bonding operation, the glass-bonding operation.

Q Would you explain a little more clearly when you wanted a gap in a predetermined band by this first method without shims, how did you select the particular, or how did you obtain or select the particular glass foil to use under those circumstances?

A For a particular tolerance band, let us say -- I will do it in metric system -- let me start again, but in metric.

For a tolerance band of 3 to 4 micrometers, we selected glass which was of about 4 micrometers and a little above, 4 to 4-1/2, something like this, and that glass we pressed between the bars to obtain our bonded bar.

Q What shape was the glass, the piece of glass that you inserted between the ferrite bars under those circumstances?

A In principal we tried to obtain these flat

pieces of glass foil as possible, but as described before, this had to be cut out of a kind of blown out baloon so they were never perfectly flat.

We cut out parts then we measured until we found things which were reasonable within the gap lengths area where we wanted to be.

Q Did the particular shape of the cut out part have any influence on the yield?

A Yes. First of all, we normally worked with bars of about one inch long and it was difficult to obtain parts which were long enough, but even if we had those, they were curved and you were never sure if you had assembled the two parts whether the glass foil between the two parts was still not broken.

For if that breaks in advance of the processs of softening, those parts will certainly give rise to trapped air or voids in the final gap.

Q Referring to the second process you described, with the shims at the end of the bar, did the pressure that you used have an effect on the yield in those cases?

A Yes. In principle the effects were the same insofar as we still, with this method, were forced to push out the excess glass, so we had to use a very high pressure to push out the relatively viscous glass between

the shims -- I am sorry, between the ferrite bars, to reach the shims or stops.

Q Was there a problem with respect to retaining the shims in place?

A Yes. With this method the glass foil where we started was thicker than the gap lengths and therefore the shims which had essentially the same thickness as the required gap length were not fixed already.

It is a situation that is even illustrated here, I believe, as this is thicker: This shim can easily move as the foil is thicker. One of the problems we had is that the glass when it was squeezed out was pushed between the shim and the ferrite part, so you never reached the required gap length but you ended at a thicker gap length or larger.

Q Which of the various problems that you have recounted to us do you consider to be the most serious in obtaining a good yield or a reasonable yield or some acceptable yield by these two processes?

A There are two very serious problems and those are trapped air or gas bubbles and gap length tolerance and I do not recall any more which of the two was more important than the other, but I think they were of equal importance.

Q In addition to those two processes that you have recounted, were there other processes which you worked with which were derived from Duinker or his group?

A No, not directly from Duinker or his group.

Q When your group began working on this problem, having entered the field, what steps were taken to attempt to solve these problems?

A I think I should make clear that our laboratory had started on the basis of the methods described so far, what we have called shortly the Duinker process and on that basis we tried to come with a solution with a product which you could make on an industrial basis. This did not work out as expected and as wanted and then there was a kind of committee that was formed from members of different groups within Philips to solve this problem.

Q Would you identify not by name but by position, the individuals who were on this committee?

A The committee consisted of Deputy Directors from the three most important parties which were evolved; the research laboratories, one from the glass laboratories and one from our materials and components division.

In addition to these three men, there were co-workers from these different groups and these people met regularly to discuss the progress, to see what steps

could be taken in the different groups in which support was needed from the groups to come out of this problem, to get it to a stage where you could produce and sell something.

THE COURT: Could I have just a moment.

(Pause)

tlpm

Q Mr. Vrolijks, you were testifying about this committee that had been formed.

Was there a name for the committee?

MR. CALIMAFDE: Your Honor, I would like to object to this question and the question that preceded it. I have difficulty finding the basis precisely for the objection but it seems unfair for a witness to be asked a question with regard to activities in Holland, committee work, personnel on committee, activity, all for the purpose of suggesting there was a problem to which the corporation was directing an effort without there being any way for opposing counsel to interrogate.

The testimony can be glibly given and I have no way of examining a witness as to the correctness or as to the exaggeration or any other way. I am just frustrated.

THE COURT: That is the purpose of discovery. I might note for the record that this case is now over four years old, so you weren't rushed to trial. I recognize your concern. At the same time I would suggest that discovery often ferrets out the truth from the non-truth.

Under the circumstances, I share with you the problem that I really find a difficulty in ascribing any legal basis for your objection and therefore I am

going to permit the questioning to resume but the evidence, of course, must be probative. I don't want him discussing things with others within his organization and coming out with all kinds of self-serving hearsay statements which would not be admissible. I will listen for that and you can object.

In other words, I think the testimony about the committee and the constituents of the committee, their names and their positions can properly be elicited.

What they discussed within the committee, I suggest, Mr. Relson, is a subject of question in my mind because of the hearsay problem.

I will let you proceed step by step but you might be aware of the point I just made.

Q Mr. Vrolijks, were you a member of this committee?

A Yes. For quite a period I was the secretary of that committee.

Q Did you participate in the work of the committee?

A Yes.

Q Would you outline what your group did as a result of the work of this committee?

A My group, the development group of which I

worked myself, we tried to obtain another means to start with to make these close gaps, so we started to get away from the baloon shape unflat glass foils.

What we did in our group was to look to other possibilities of providing the glass for the gap and one of the things we did was that we squeezed out glass rods which were placed on the polished gap forming surfaces to obtain the glass gaps as required.

Q Would you describe that using the simulation if at all possible so we get a clearer idea of how that was done?

A I think it is very simple. Here we have the same model. We put shims on the end and we used instead of this foil, we used rods.

MR. RELSON: Your Honor, we have a couple of unmarked glass rods. If counsel does not object, the witness might use them or else we might actually mark them, although they have not been previously marked.

THE COURT: I think if you are going to use them and they will be referred to, they should be marked for identification. We will call these two glass rods.

(Plaintiff's Exhibits 171-H and I were marked for identification)

MR. CALIMAFDE: I have no objection to them

going in.

THE COURT: They will be received, although they are actually being used for demonstration purposes.

MR. RELSON: Before we receive these in evidence, if you wish to use these in your deliberations, we will be happy to have them received in evidence otherwise they are awkward to take care of and it might be more convenient to merely consider them for identification and not make them part of the file record.

THE COURT: At the moment we will just mark them for identification. They do get cumbersome if they are needed for appeal. If anyone wants to move their admission later, they may do so. We will keep them for identification now. That whole 171 series will be for identification.

Q With the aid of these two rods, can you illustrate the process to which you have referred?

A Yes. Except the fact they are too long, but they have to be placed between the shims at the end of the bar, and again I will do it correct on your side so you see what is done. Both sides should be as shown here. In this method care must be taken that if they are squeezed out that the glass does not creep under the shim. So, in addition, it is necessary or advisable to make slots between the glass rod and the shims on both sides again. Then the upper part is placed on it.

THE COURT: Then heat is applied?

THE WITNESS: Heat and pressure is applied.

THE COURT: And the glass in a softened condition spreads laterally or sideways?

THE WITNESS: Sideways, in this direction.

THE COURT: Indicating laterally or sideways.

THE WITNESS: You really have to do something in this method for the assembly. It easily slips over it and these large parts more easily than the actual parts.

THE COURT: I understand what you're doing.

So you progressed from the curved glass and now you have reached the point where you are using the rods?

THE WITNESS: Yes, your Honor.

THE COURT: Did I miss some stage of the glass curved piece? You had a problem with that then, the rods?

THE WITNESS: That is what we did in our laboratory. In addition, other work was done to find solutions.

THE COURT: Did you always, up to this point at least, use the same type of what I will call glass, or did you change the formula for that?

THE WITNESS: No. Up until this point we used the same type of glass.

Q Was a patent applied for on this last process?

A Yes. Jan Visser and myself applied for a patent

on this process.

MR. RELSON: I have a copy of this patent although not listed among our exhibits, was marked as an exhibit on a deposition of Mr. Vrolijks' taken a week or ten days ago by the defendants and I would ask leave to offer this for identification.

MR. CALIMAFDE: I have no objection to it so it may go right into evidence, if you wish.

(Plaintiff's Exhibit 248, received in evidence.)

Q I hand you patent 248. Is that the patent to which you had reference or not?

A Yes, it is the patent to which I had reference.

THE COURT: I note in the figure, particularly in figures 1 and 3, what here were round glass rods, there appear to have been square glass rods. Am I correct?

THE WITNESS: That is correct. Both forms can be used.

Q What does figure 1 of this patent illustrate?

A Figure 1 illustrates the U-shaped bar, ferrite bar, with the two glass rods on it together with the four shims.

Q Shims in the corners?

A Yes.

Q What does figure 2 illustrate?

A Figure 2 illustrates the other part which will be placed on top of the assembly.

Q What does figure 3 illustrate?

A Figure 3 illustrates the combination which is obtained if this second part is placed on the first part and it shows only half of the non-bonded sandwich.

THE COURT: I am sorry, I didn't understand what was just said. Only half --

THE WITNESS: Of the non-bonded sandwich. You will note that figure 3 is shorter than figures 1 and 2. They have cut it off to show only part of it.

Q Mr. Vrolijks, in the lefthand side of figure 3, I can see the end of this rectangular rod but it is not clear what position it has. Would you explain what position it has with respect to the upper and lower ferrite pieces?

A It should be placed on the lower part and it should be under the polished surface of the upper part and this is doubtful here, and even, I think it is a draftsman's error, maybe, but in the patent itself it is stated clearly that the glass is placed between the two polished surfaces, respectively on that side, on the left side of the drawing, references 7 and 2. That is stated in the patent.

Q Approximately what was the size of this rod in

relation to the height of these shims?

A For the size of the rod, we chose a value that would fill the entire glass gap we wanted to make and have an excess of about one-third.

So, it depends completely on the polished surface of this bar.

In the case that we worked, the types we used, this surface was four milimeters or .15 of an inch. Then for a glass gap of the order of four micrometers, you need a glass rod with a much larger diameter. I think it is in the order of sixty or seventy micrometers but we could make the calculation very roughly.

Is that sufficiently clear?

Q I think so.

In connection with this last form, is it or is it not correct that the ferrite bars initially, before the application of heat, were more widely separated than the ferrite bars in the preceding types of processes that you have testified to?

A That is correct. In this case the separation was, as I said, up to sixty, seventy microns and the other only slightly above the required gap length.

Q What was the result of this process with respect to improving yield?

A With this method, we succeeded in producing glass gaps with much less air bubbles than in the process described before with the glass foil. So, we really had progressed, but this method had the quite serious drawback that we had to apply a rather high pressure to get the glass down to the required thickness.

Q How did the pressure in this method compare with the pressures in the preceding method you have described?

A I do not recall those figures anymore. The only thing I know is that we had to go on to higher pressures. I knew this for we had to make changes on our furnaces we were using.

Q Would you generally describe what other steps were taken by your group in an effort to improve yield.

A We asked the glass laboratories whether there were no other means to obtain glass foils. So, instead of the blowing method, they tried an extrusion method to produce a nicely shaped glass foil --

THE WITNESS: May I make a sketch, your Honor?

THE COURT: Yes, you may.

A They tried to make something like this shape, where this actually was the glass, the thickness of the required glass gap and these were just supporting rods.

The idea was that this, if the extrusion method

worked, we could use this in a very easy method. It would be good to handle and there were some parts made but it appeared that it was not possible to really come to the thin values we wanted here and also the tolerance band needed was much larger than we could accept.

THE COURT: Let me hear the last answer.

(Answer read.)

THE COURT: Mr. Vrolijks, you have drawn on the blackboard, a diagram of something which looks to be a bar with a ball at each end.

THE WITNESS: What I show you here is just a cross section of the glass foil we were trying to make.

In another projection you would see this. This is the upper side here and the same here, and there is the glass foil inbetween.

Q Is the lower diagram looking flat down on top of the other diagram?

A Yes, on top.

THE COURT: Are the two ends that you have drawn on the blackboard, are they circular? Are they round or are they flat?

THE WITNESS: They are more or less round in this direction. They are like sticks. You could imagine like two rods like this, with inbetween, the glass foil.

THE COURT: I understand now. In other words, you had taken the two things and more or less put them together. You had the foil which was flat and now took the rods and put them to either side of the foil.

THE WITNESS: Yes, but the only thing we would use in this case was the foil. The extra glass would just soften and not be used. Only the foil inbetween the two would be used.

THE COURT: And the purpose there would be to permit the foil, as I see it, to be bonded to the ferrite with a minimum loss of the foil and a minimum of air bubbles between the foil and the ferrite.

THE WITNESS: Yes. As the foil was flat, you would have much less problems with air bubbles.

THE COURT: Thank you.

Q The two cylindrical edges to this structure you described, were they placed between the ferrite pieces?

A No. These cylindrical things, we have only done a few things with it. The ferrite part would come here on one side and the other part here, so this would be finally the ferrite.

Q So that merely the flat part was between the ferrite pieces?

A Only the flat foil part was being used. This

worked, but the method of extrusion didn't work, so this solution had to be discarded.

Q Would you state whether or not attempts were made to use glass powder in emulsion form?

MR. CALIMAFDE: I missed the first part of the question.

(Question read.)

A The people of the research labs had worked on that line --

MR. CALIMAFDE: That is objectionable, for hearsay.

THE COURT: These people who were doing the research, did you work with them at any time?

THE WITNESS: Yes. If I may clarify how we worked there and that is that I was the man who had to try a pilot production-type basis, so if the people on the research lab tried something, they would come up with their samples and we would try to see whether or not they worked.

We worked with a colloid chemical group which made the emulsions of the glass. They made a film of it so there was a film of glass powder in a type of carrier and those parts were used in our laboratory to try whether or not we could make useful heads with it.

MR. RELSON: Your Honor, we have made a replica

of the blackboard on which the witness made his sketches. I have shown it to opposing counsel who has placed the legend on it "Vrolijks' sketch on blackboard," and with counsel's consent, I will offer this in evidence as Plaintiff's next exhibit.

(Plaintiff's Exhibit 249 was received in evidence.)

THE COURT: Very well. It appears to be an accurate representation of what was drawn on the blackboard and as I understand there is no objection.

MR. RELSON: I have no comment to make on Exhibit 248, the patent that the witness described a moment ago. This patent is not prior art to the invention in suit because of the dates appearing thereon.

By patent in suit, I necessarily meant the Peloschek patent because it is later than the other.

Q Mr. Vrolijks, you were describing a variation of the process using a glass powder emulsion. What was the result of that process with respect to yield?

MR. CALIMAFDE: Let me make this one last objection to this area of examination. Then I will not make any further objections.

The problem I am having is the same problem I indicated previously, that we are in this area where I am

* * *

that the witness was produced without the necessity of subpoena. I don't think you can use a sword and not give the other fellow a shield. But I will leave that for the moment. Let's move on.

BY MR. RELSON:

Q Mr. Vrolijks, with respect to the last form of process to which you testified, involving the use of a glass powder emulsion, would you state what effect was produced on the yield of course by the use of that glass powder emulsion?

A The use of glass powder emulsion as a means to produce glass gaps was not successful as we had quite some problems in trapped air, in air bubbles in the final gaps.

So to my recollection we did not proceed so far that we came to a conclusion about yield. The experiments were very bad and we abandoned this line.

Q I want to make one point clear, if you can do so for us. Would you compare this glass powder emulsion form with the earliest of the processes that you have testified to, that is, the glass foil form without shims, and tell us to what extent they are similar and to what extent they differ.

A These two methods are similar in the extent that in both methods you place the glass between the two parts, the upper and the lower part of that assembly.

The method as we tried the emulsion method was

that there was a pre-glazing step to let the glass flow out, melt, before the actual bonding took place.

Q Was the present glazing step done before or after the two ferrite pieces were placed on either side of the emulsion?

A In the experiments we did both but to get some reasonable gap, you had to do it before assembling the two parts and even then we still had a problem with a lot of trapped air.

Q That isn't clear to me. Would you illustrate it by means of simulation before you?

A Now we assume that this foil does not really represent glass but an emulsion of glass -- I am sorry.

This foil simulates --

THE COURT: Powder?

A -- placed here the powder brought on the ferrite surfaces by different means but all out of an emulsion. A emulsion in water or other liquid was -- placed is not the right word.

Q Deposited?

A You could say it was spread.

THE COURT: Painted?

THE WITNESS: You would not have any accuracy at all but similar means.

THE COURT: Could you spray it on?

THE WITNESS: No. The most successful was

that the parts were placed in a centrifuge in the bottom of a jar in which the powder was in a solution. As the centrifuge turns, the powder is moved to the side for it is heavier than the liquid so it ended on the ferrite parts.

THE COURT: Was that also in the centrifuge, the ferrite part?

THE WITNESS: Yes. It was one of the methods we tried. Another method was an emulsion just poured out, let it dry, then you get something like this but with all glass particles in an organic carrier.

THE COURT: Then heat and pressure was used in an attempt to bond the two ferrite edges; is that it?

THE WITNESS: The two parts, the two methods we followed then was after getting the suspension or the emulsion on the bars, was to put immediately the other bar on top --

Q Were the shims used in that case?

A The shims were used in that method. We would put the other bar on top with a slight pressure, heat and obtain a glass bond.

As I said before, this method gave rise to a lot of air bubbles, then we decided to pre-glaze the

surfaces then put the second bar on top of the first bar afterwards.

Q In pre-glazing, would you explain what you mean by that?

A The bottom bar was heated to a temperature at which the glass melted. It covered completely the surface then the bottom or bar was cooled down and the cover bar, the top bar was placed on top of it and the assembly was heated again under pressure.

That essentially describes some of the variations we tried, the most important ones.

Q Thank you.

Now, would you describe the origination and development of the process that is described in your Patent No. 3246383?

THE COURT: The so-called Peloschek patent.

MR. RELSON: Yes, sir.

A In the course of the developments we had tried different methods and we still did not get a reasonable yield. So, Peloschek and myself spent much time in discussing the problems, trying to get out the points where we thought, where do we see a chance for success, and one of the things we decided to try was to

place the glass not inside the gap but adjacent to the gap to see whether it would flow in.

Q Would you state whether or not you expected it would flow in.

A No. The problem was that-- of course we doubted very much that it would flow in for the gap which had to be filled was very small, very minute, of the order of 3 to 4 micrometers, the smallest gaps we were working with then and we wanted to flow the gap all through to fill a 4 millimeter depth of the pole piece seen in the direction here square through the gap.

If you want to understand somewhat more, it could be compared as of a gap of say a quarter of an inch had to be filled and the glass had to flow over a length of more than 30 feet, so we were not sure that it would succeed.

Also, we were hesitent to go to a high temperature which would make the glass sufficiently liquid to fill that slot for we were afraid that at the high temperature, the glass would react with the ferrite and deteriorate the ferrite surface which in effect would then cause effectively a larger gap length and that is just what we did not want.

Q Will you explain what you mean by effectively?

* * *

Q We were talking about an effective gap. Does that have a different length from the physical length?

A It generally has.

Q So physically it looks like a certain length, but logically it behaves as though it had a different length?

A That's correct.

Q Is that different longer or shorter than the actual length?

A That is always longer -- if there is a difference, it is always longer than the physical gap.

Q So that whatever causes the effective length to differ from the physical length causes the gap to be apparently a longer gap?

A That's correct.

MR. RELSON: I think that is the concept that we need for this matter, your Honor. How we measure it I don't think comes into this at all.

Q What kinds of things cause the effective gap length to differ from the physical gap length?

A One of the possibilities is chemical reaction between the glass and the ferrite surface. Then the ferrite surface will become less magnetic, the magnetic properties can change, and therefore it may seem as if the gap is longer, and that is an effect which we do not want, for we want to

have short gap lengths to be able to read very short wave lengths.

Q Would you state again what caused this interaction which affected the ferrite and thereby increased the effective wave length?

A I would like -- there was a possibility in going to glasses which would melt to really very thin fluid that they would react easily with the ferrite, but that is one of the disadvantages or possible disadvantages or problems we could expect in using this method of capillary action, where the thin glass is flowing into the gap.

MR. RELSON: Your Honor, I think we can break here, if it is acceptable.

THE COURT: Yes, it is.

We will recess at this time. We will resume tomorrow morning at 10 a.m. Good night everyone.

(Adjourned to 10 a.m. June 12, 1975.)

* * *

MR. CALIMAFDE: All right, sir.

May I ask when we might expect these minutes? Are you going to make a request tonight that they be forwarded to us promptly?

MR. RELSON: They will be forwarded by special delivery mail. If everything goes well, you should have them Monday.

MR. CALIMAFDE: All I can do is ask you to request them today. If the mails get them here by Monday, that's fine.

MR. RELSON: They will certainly be in the mails at the earliest moment.

THE COURT: Thank you.

MR. CALIMAFDE: Thank you.

THE COURT: You may proceed, Mr. Kelson.

DIRECT EXAMINATION CONTINUED

BY MR. RELSON:

Q Mr. Vrolijks, in the course of your testimony you have referred a number of times to tolerance, I belive the Court did on one occasion, some of the patents do, to the word tolerance.

A Yes.

Q I would like you to advise the Court as to what is meant by the term and its significance and importance

and applicability?

In other words, clear up what is involved in the consideration of tolerance.

A For these magnetic heads, the tolerance of the gap length is of great importance as it determines the resolution, the frequencies which still can be manufactured.

Q First as a preliminary, would you state what a tolerance is, what is meant by a tolerance?

A Tolerance is the bend in which a certain dimension may vary and still meet the specification.

You can specify a tolerance in two ways. You can say a certain dimension has to be five plus or minus one. You can also say the tolerance band is from four to six.

THE COURT: When you are within that tolerance band, you have what might be called optimum resolution; is that correct?

THE WITNESS: For the specific application in which that magnetic recording head is used.

Q Would you explain how tolerances are arrived at in connection with a situation like this where you have a component, namely, a head or core, and a system in which that component is being used?

A The very general situation is such that the systems people always want to obtain something with tolerance zero and that the components people always want to make a wide tolerance. This enables them to get high yields.

Q How does that affect the question of cost?

A Components with tolerance zero will be extremely expensive. So in practice you try to find a compromise between the requirements of the systems people and the capability of the components people.

Q Why do the systems people desire small tolerances?

A If they have small tolerances, they are all electronic designed, in this case after the magnetic head, becomes much easier. They don't have to make up for variations of output due to variations in gap lengths tolerance and variations in resolution.

Q Would you explain how output and gap length are related, in a general way?

A It is a rather complicated story. In a very general way you can say that the shortest wavelength or bit lengths which is recorded in reading this, when the gap is relatively large, you get a low output. When the gap is smaller, you get the output you want.

But if you make the gap too small, the

efficiency of the head drops again and the output drops. So that means there is for a particular situation with a certain bit density or bit length, a certain distance between the recording media and the heads. There is an optimal gap length.

I think it is very complicated. Sorry, your Honor. I can't explain this easy.

Q In general then, there is a relationship because of which the systems people would like the tolerances specified narrowly; is that or is that not correct?

A That is correct, yes.

Q Take the viewpoint of the component people, like the head or core makers.

What is the effect of tolerance and why do they desire, as you indicated,a wider tolerance?

A The gap lengths we are considering here are of the order to hundreds to two hundred micoinches. It has proven to be difficult to produce those gap lengths with small tolerances.

Therefore, the components people like to have large tolerances.

They are looking, of course, if in the process of a production to find means to reduce the tolerance, to obtain more yield within the required tolerance band.

* * *

these heads, that we had much rejects on gap lengths variations which gave lots of heads outside the specified tolerance band.

Q Were the research groups concerned in the same way in obtaining high yield for narrow tolerance bands?

A The research group produced much less heads. They made some heads for evaluation. So they were not concerned in the same way as we were about tolerance. They were happy when they had few heads to do further experiments with.

Q Was your group concerned with the mass production aspects fo heads and cores?

A Our group was responsible to obtain a process which was useable for larger quantity production. I would not use the word mass production for that. I think in the order of millions per week. We never thought of that for recording heads.

Q But of large scale commercial production.

A Large scale commercial production, yes.

Q Would you state in a general way to what extent the work of the research group which was supplied to your grcup and which you indicated had been tried out by your group, to what extent that work satisfied requirements for good yield in narrow tolerance bands?

A That did not satisfy this requirements mainly due to the cause that we could not obtain glass foils with the correct thickness. That was the major problem using the approach with the foils.

THE COURT: What period of time are you talking about now?

THE WITNESS: I'm talking about '61.

Q If you turn to the Peloschek patent. I believe you have a copy, don't you?

A No, I don't have.

Q Here you are.

(Handing)

A Thank you.

Q Would you explain to the Court the process of that patent with reference to Figure 1 of the patent, and if you find it useful, you may use the simulation that is before you to illustrate your testimony?

A Yes. I would like to do that, for that makes it much easier.

So again we have the ferrits bars on which the shims are placed to determine the gap length.

In this case we used rods which were of another material than the rods referred to yesterday. They were of low melting glass. These were placed. After

that we put these two assemblies together.

THE COURT: You used four shims?

THE WITNESS: We used four shims.

THE COURT: That's for the gap length.

THE WITNESS: That's for the gap lengths. A neck form here, our American friends call that an apex.

There the glass rod was placed in that apex. I will put one in on this side.

We used rods which were somewhat shorter so that they were between the shims. That's not essential.

THE COURT: The rods were not put as in previous experiments or models between the ferrits faces, they were placed in what you call a neck or an apex.

THE WITNESS: Yes.

THE COURT: As I observe it, to the side of the ferrite faces.

THE WITNESS: Yes. They are placed on one ferrite face, on this flat one of the lower one. There they are placed on. They are not between the two mating surfaces. They are against the other one.

THE COURT: You say this was a different type of component, the glass?

THE WITNESS: The glass, yes.

Q At least in this condition would you call

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what you have a sandwich?

A It is not yet a sandwich. There's nothing between the two points of the sandwich, the two ferrite bars.

THE COURT: This looks like a frankfurter before you put the frankfurter between the two halves of the roll.

I am afraid this is turning into a cooking exercise which I didn't intend. I can observe what you have done.

Would you proceed from there.

MR. CALIMAFDE: If I may, your Honor. I belive you were asked to describe the process that is disclosed in the Peloschek patent and reference was made to a glass rod of a low melting point temperature.

I have trouble finding that in your patent. Can you tell me where I might find that in your patent?

MR. RELSON: May I conduct my examination, your Honor?

THE COURT: Yes, indeed. I find that an inappropriate question at this time. Therefore, I will sustain the objection. I marked that one down for cross examination if it is not covered.

MR. CALIMAFDE: All right, sir.

THE COURT: Let's proceed.

A (Continuing) This assembly is heated up to the melting temperature of the glass rods applying relatively light pressure on the assembly.

THE COURT: What are the shims made of?

THE WITNESS: The shims can be made of mica or metal.

THE COURT: With a higher melting point than the glass, I would assume?

THE WITNESS: That's certainly true, yes.

Q Would you compare what you have referred to as the melting point or melting --

THE COURT: Temperature, I believe he said.

Q -- temperature with your previous discussion about what I will call the sandwich process in which you referred to the softening of the glass?

A In the other processes the glass was heated to a temperature where it would under pressure -- could obtain another shape, whereas in -- and that we call softenings.

In this situation the glass melts to a relatively thin fluid. Fluid is the right word.

THE COURT: It turns to a liquid instead of a solid?

THE WITNESS: Yes, like a liquid.

A (Continuing) Then it fills the gap if it is adjacent to it.

Q What causes the glass to fill the gap?

A That is a phenomena which is called capillary action or capillary activity. That's a phenomena that is known, if you have a thin tube --

THE COURT: And the liquid will rise within the tube higher than if it had not been within the tube?

THE WITNESS: That's correct.

MR. RELSON: Your Honor, I would refer you to Exhibit 172 in our book, which I offer for identification.

(Plaintiff's Exhibit 172 marked for identification)

THE COURT: Is there any objection to that which is the principle of capillary action?

MR. CALIMAFDE: No, sir. I don't see any objection to it.

THE COURT: I think we can all go back to our first course in physics for that one.

(Plaintiff's Exhibit 172 for identification received in evidence)

Q Just for the record, Mr. Vrolijks, would you briefly explain what capillary action is, referring to

Exhibit 172 as you find desirable?

A I think the sketches are very clear here. The Figure B shows a situation --

Q Would you start with Figure A as a background.

A Okay.

In Figure A there is a -- a plate is placed in the liquid and small meniscus is formed due to the surface tension of the liquid. It creeps up a little against the plate.

Q Is that what is called wetting action?

A That's the wetting action.

THE COURT: We are not going to be talking about wetting action, we are going to be talked about capillary action; is that right?

THE WITNESS: That's correct, your Honor.

THE COURT: Would you proceed to B.

A (Continuing) The Figure B which shows capillary action, you will note there is a tube placed in the liquid and due to the capillary action the liquid in the tube rises to a height higher than the liquid in the surrounding gap.

THE COURT: The height can be reduced to a mathematical formula, can it not?

THE WITNESS: Yes, it can. It is shown here

below that -- how you can calculate the height if you know the various parameters. As the wetting angle, you need for that the radius of the tube and the density of the liquid.

In this case where the liquid has to rise against gravity, the density comes in the picture.

Q Is capillary action dependent upon the wetting action?

A Yes. It is influenced by the wetting angle and, therefore, it -- the height will be influenced by the -- by what we call wetting action.

THE COURT: Actually the height at the top will not be horizontal, but rather will be in the form of a --

THE WITNESS: Meniscus again.

THE COURT: Meniscus due to wetting action at each side?

THE WITNESS: Yes, your Honor.

3 a.m.



Q In the case of the bonding of the ferrite pole pieces, would you state whether or not the gap is disposed horizontally or vertically?

A It is disposed horizontally as shown here in this example and that is what we did, I think in all cases.

Q Is there a restriction which requires that the surfaces of the gap be disposed horizontally?

A No, it is not a restriction.

Q Is there an advantage to having it horizontal?

A Yes. In that case you do not have the gravity force which would try to get it in the other direction, but it is possible to do it vertically.

THE COURT: If you did it vertically, thus turning the entire device, it would seem to me if you had the rods on the inside, capillary action would have to work up on one side against gravity and down on the other side working with gravity.

Therefore, by keeping it horizontal, you have cancelled out the gravity effect.

THE WITNESS: Yes, but in other head constructions where they were not all symmetrical constructions when made, so it was attractive to fill some areas in a vertical position.

THE COURT: In any event, capillary action will

work whether the action is vertical or horizontal; is that correct?

THE WITNESS: That is correct.

Q If the gap were vertical, as we have been discussing, would the glass flow into the gap merely because of gravity?

A It depends. I just explained it can even flow against gravity. In the other case, where gravity would help the glass, both phenomena would help to fill the gap.

Q Would gravity alone be appropriate to fill the gap with dimensions of this type?

A I don't know, but I think itis a theoretical question.

THE COURT: In any event, your method did not utilize that particular procedure?

A No.

Q You have discussed your method up to the point of heating the glass to this relatively fluid state by which the glass then enters the gap?

THE COURT: And filling the gap by capillary action.

THE WITNESS: Yes.

Q Thereafter, what is done?

A Thereafter the assembly had to be cooled down,

the glass solidified inside the gap and the head could be machined as required to pole pieces or multi-track head or whatever was needed. This was one of the points of the invention.

Q Does the glass, during the course of this bonding process, fill the gap entirely from inside toward the outside?

A Yes. The glass fills the gap but we had some problems with that filling and we had to fill a rather long channel and it appeared sometimes that air was trapped so that the glass did not fill the gap completely.

Q What was the amount of glass that was supplied in the form of the fish rods in relation to the volume of glass that would get into the gap?

A It was many times larger than was needed. I would have to make a calculation. I still remember what type of rods we used.

Q Generally it was larger?

A Yes, we used rods of 100, 200 micrometer diameter.

Q Was that done deliberately?

A Yes, to be sure first you had enough glass and secondly, the excess glass formed a fillet, filled the neck between the two parts, thus reinforcing the parts.

THE COURT: I think we saw a diagram of that yesterday.

MR. RELSON: That was in another context in the Duinker patent, your Honor.

THE COURT: But the same result would be here.

In other words, this was an extra-strengthening agent?

THE WITNESS: That is correct.

MR. RELSON: The one difference is that special provisions had to be made in the Duinker patent and in this instance, the fillet --

THE COURT: As a result of putting in this extra quantity of glass?

THE WITNESS: Yes.

MR. RELSON: I have here another part of the simulation which is marked 171G, which I will simply offer for identification as we did with the remainder.

(Plaintiff's Exhibit 171G, marked for identification.)

Q Using 171G, can you illustrate how the bonded-bar after bonding is subdivided for the purpose of obtaining individual core pieces?

A Yes. In most instances we cut the bars in this direction first.

THE COURT: Lengthwise.

A So we obtained half a broodje. A channel-shaped part with a gap on one side and open on the other side. That part was then sliced into parts like this, this direction, then just slice it, depending on the thickness of the cores which were required.

THE COURT: This, to use the same analogy,is something like making a hero sandwich which you then cut down and get different pieces within that.

Do you know what a "hero sandwich" is?
It is an Italian sandwich.

THE WITNESS: You can't get it inbetween your mouth.

THE COURT: That is basically what you have done.

You are cutting at right angles?

THE WITNESS: Yes.

THE COURT: When are the cuts made in the Peloschek method; are they made after the glass has hardened and before the machining process?

THE WITNESS: Which cuts?

THE COURT: The crosswise cuts.

THE WITNESS: First the glass has hardened, the assembly has cooled down, then we start with different machining

operations. It depends on the application whether you do already some polishing before slicing or after, but generally that is done later.

Q Does the simulation also indicate the glass fillet that has been referred to?

A The simulation? Yes, that is true. It is a clear example, somewhat exaggerated, of a glass fillet.

Q Would you describe the types of machining, or I will call them finishing operations that are applied to the piece after it is sliced from the long channel-shaped bar?

THE COURT: After the lengthwise and after the crosswise slicing has been completed, is that it?

Q Once you have the U-shaped pieces that is shown with the two legs bonded together.

A That depends entirely on the head you want to make.

Q Would you direct your attention to what is conventionally in the use of such heads in magnetic disc files for computer purposes?

MR. CALIMAFDE: Your Honor, in an effort to save some time, I don't think either patent in suit has anything to do with machining, polishing. If this is of interest to the Court, I would have no objection, but I don't see the relevancy of the witness describing this .

* * *

Q In general, do you have an awareness of how many cores are purchased by a head manufacturer to make a given number of heads, let's say, how many cores would he need for one hundred heads, approximate figure from your knowledge.

A It's very largely, and the figures I have been informed of, went from the double quantity --

MR. CALIMAFDE: Again, your Honor, the figures he has been informed of. We are getting a lot of vague testimony. I don't like to object, but to fill the record with vague testimony on what was told to him, it doesn't help anybody.

THE COURT: Do you want to withdraw the question?

MR. RELSON: Yes.

Q Going back to the bonding process which you have described in connection with your patent, what has been your experience with respect to the problem of bubbles as a result of this process?

A With this process we have obtained good heads and the occurrence of bubbles was much lower than in the other processes we tried. We experienced it as a medium improvement.

Q What was your experience with respect to the problem of keeping close tolerances for gap length?

A We obtained with this method much closer tolerances. We had to reject much less heads on the basis of gap lengths tolerance. In this respect, it was really an improvement.

Q What was the effect on yield?

A The total effect on yield was that with this method, we rather rapidly obtained yields up to 90 percent.

THE COURT: From what?

THE WITNESS: Previously we were as low as 5 and 10 and gradually had something like 50 percent yield with the rod method.

Q Previously with those yields consistent in value?

A No, they were not consistent. They varied largely due to the -- the method was not predictable, completely.

Q What factors in what I will call the Peloschek method or capillary method, what factors in the capillary method made more predictable the gap length as you just testified?

A The major advantage of this method was that the spaces were put in place in their position and clamped

between the two parts whereas in all the other methods using stops described before, the upper bar was always somewhat -- at a somewhat larger distance from the spacer due to the glass foil which was thicker or the glass rod which was significantly thinner.

THE COURT: Which was really an additional spacer, actually.

Now, you are only using the shims or single type spacer whereas before you had used two types of spacers as I recall it, the shim plus, for example, the foil.

THE WITNESS: Which had to be pressed out.

THE COURT: And which laid between the shims?

THE WITNESS: Yes. The shims acted there as stops. In this case, the spaces were on their position the moment the assembly was clamped. The spacers could not move, they could not curl, they could not so easily oxidize as in the other methods and in our opinion, that was the major advantage of this method.

Q Would you explain the oxidation of shims and what its effect was? First, when did such oxidation occur, under what circumstances?

A At the pre-heating of the assembly to the softening temperature of the glass.

* * *

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found a folded shim and with a too large gap length.

Q How was that problem overcome, if at all, in the capillary process?

A In the capillary process, the shims were placed in their position.

THE COURT: And the assembly was clamped before the heat process was applied, is that correct?

THE WITNESS: That is correct, so they had no place to go, other than to stay where they were.

Q I would like to refer you to the patent, if you have a copy there and to line 41 of Column 1, which refers to the melting point of said glass or enamel.

It says, "The maximum melting point of said glass or enamel being 900 degrees C."

A Yes.

Q What was the reason for imposing a maximum melting point on the glass or enamel?

A We had done some experiments with glasses which melted at a higher temperature and we found that reaction between the ferrite and the glass took place, so that is the reason why we put our limit there.

Q Did that reaction have an affect on the gap length?

A It was clearly noticed that the straight gap

* * *

Q May it be under some conditions a glazed material?

A Yes. You can use it as a glazed or glazing material.

MR. RELSON: Was your Honor using the term glaze or glazed?

THE COURT: Glazed, with a D.

Q In the patent at Column 1, Line 47, it says, "In order to prevent the liquid enamel from flowing between the spacing members and the parts according to an embodiment of the invention, the parts may be pressed together with a slight pressure during the heating."

Would you compare the pressure that is used in the capillary process with the pressure that was used in the prior sandwich type process?

A Yes. The pressure in this capillary process was a factor of 5 to 10 smaller than the pressure we used in the previous described processes based on glass foil and glass rods. This gave us the advantage that the bending of the ferrite bars under the high temperature was much less and this was one of the reasons that we obtained less rejects and gap length variations.

Q Would you explain the factor of the bending of the bars?

A When you use high pressures on a ceramic material, specifically at the high temperatures involved, the material will deform somewhat and that will cause variations in the gap lengths at different places.

Q Does that make the various cores produced non-uniform in gap length?

A That can result in a case that if you slice from one-half bread, you get gap lengths of different values over the slice of the bread.

Q Are those values significant in relationship to the type of tolerances that are required for gap lengths in a practical sense?

A Certainly. We have found large variations over the gap lengths, meaning that part of the heads even out of a sandwich which we thought was a good one, had to be rejected.

Q Because of non-uniformity of the gap lengths?

A Because of non-uniformity.

Q And you are referring to gap lengths from the same bar.

A Yes.

Q Would you compare that with the situation in the capillary process?

A As I said, in the capillary process, this was

improved considerably so in total at the time we had reasonable control over the whole method, we obtained yields up to 90 percent.

Q You mentioned yesterday something about cracking of the ferrite pieces under pressure. Do you recall that?

A Yes, I recall that.

Q Was that in connection with the sandwich process?

A That was in connection with the sandwich process.

THE COURT: Cracking or crumbling?

THE WITNESS: Cracking.

MR. RELSON: I think crumbling had been used in connection with what Mr.Kornei called the sharp-knife edge and cracking is a different phenomena.

Q Is cracking of the ferrite pieces in the capillary process a significant problem?

A No.

Q Is that a result of the different pressures?

A Yes, in our opinion it was.

Q The patent in Column 1, Line 51 says: "According to another aspect of the invention, each of the parts is heated for a short period of time at a temperature of 800 to 1000 degrees C before the surfaces are placed in

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of N.V. Philips take, in filing the first application on your invention?

A That first application was filed in May, 1962 and due to the pressure of our department to get it filed --

MR. CALIMAFDE: That is objectionable.

THE COURT: I don't think it will add very much but I will leave it.

Q You mentioned with respect to the sandwich process that at times glass would enter between the shim stop and the ferrite surface above it.

Was that also experienced in your capillary process?

A No, in this method, a small pressure, as I mentioned earlier, if you used that relatively small pressure, you prevent the glass creeping between the shims or spacers and the ferrite blocks. It is in effect the same advantage. The shims are there, they are kept in their same position, they don't change, you heat up the assembly and cool it down.

Q In a capillary process, were the shims pushed out in the bonding process?

A No, they were not.

Q After the capillary process had been tried out

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by your group, did it get into production?

A Yes, we went into production on the basis of this technique.

Q Did the sandwich process get into production?

A No, the sandwich process did not get into production.

Q What was the process or processes used thereafter by N.V. Philips in the production of glass-bonded ferrite cores?

A This technology capillary providing the gap material.

Q I want to refer you to Column 1, Line 38, the sentence there which speaks of the interposition of spacing members having a thickness equal to the desired gap length.

How critical was maintaining the equality of the spacing member thickness to the required gap length?

A I am sorry.

Q Was it critical to maintain the spacing equal to the desired gap length in a capillary process?

A The spacing thickness or the thickness of the spacers had to be chosen within the tolerance band of the gap lengths later required.

THE COURT: When you say spacer, that is synonymous to shims?

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A glass-bonded ferrite core does not necessarily mean the core described in the patents in suit.

THE COURT: So far he hasn't established that, I agree with you.

MR. CALIMAFDE: The expression is taking on perhaps a patented meaning.

THE COURT: Not yet. Maybe it will, but not yet.

Q Approximately when did the Model 2314 disc file become commercial?

A That I don't remember.

Q Are you acquainted with an IBM disc file known as the Model 3330?

A I am acquainted with the heads for the disc file and in that connection I have instituted specifications of the disc file itself.

Q Do you know the bit density for that disc file?

A Yes. It was over 4,000. I think 4,400 bits per inch.

Q Does that disc file use glass-bonded ferrite cores for the recording heads?

A Yes, it does.

Q In general, what can you tell us about the

* * *

A I said that is correct that in the area of the glasses, the enamels have the lower melting point, but they are part of that family to my understanding.

Q Let me talk with you, Mr. Vrolijks, about the Duinker process as it was turned over to you back in I think you said 1961, is that right?

A Yes.

Q Am I correct in understanding that a Duinker process in terms of a technique as well as in terms of materials were handed to your group for further work?

MR. RELSON: Your Honor, I have an objection to the characterization of the Duinker process in the singular since there has been discussion of a variety of other processes that might be characterized generically.

THE COURT: Your objection goes to the form of his question and I will sustain it. I will ask that he restructure his question.

Q I am talking about the process, Mr. Vrolijks, which was the first one given to you when you were transferred from one division or laboratory in the N.V. Philips Company to another, and as I understood your testimony, when you were assigned to this new area of responsibility, you began to work on what I thought you characterized as a Duinker process with the glass foil.

A That is correct.

Q That is what I am talking bout, at least in this area of the examination. I am talking about that process and those materials.

As I understand your testimony, that process involved the interposing of a glass foil between ferrite pieces and that the ferrite and the glass had, matching coefficients, as far as you knew?

A Yes.

Q Can we develop a shorthand expression for the coefficient of thermal expansion such as CTE? If I refer to that, do we understand each other?

A We did not think in those terms. We thought in a matched expansion over the range.

Q Let's call it what, matching coefficients over a range?

A Yes.

Q What range?

A The range from where the glass became solid to room temperature.

Q That is called a transformation point where it becomes solid? In other words, the point from where the glass is no longer soft, it becomes solid down to room temperature, that is the range you are talking about?

* * *

was no testimony that materials were obtained, that is, physical materials, were obtained from Duinker.

Q When you were handed this project was it handed to you with ferrites and with glass?

A I think I made clear before that I was -- at a certain moment I had to join this project when it was already under investigation in our laboratory. So I did not get it direct from Duinker, but somebody else --

Q All right. When you were assigned to it.

A When I was assigned to the project it was already in our laboratory and they were using the glass foil technique.

Q This is what you understood to be the Duinker technique?

A This is what I knew as the technique from Duinker and his group, yes.

Q This is what you had read in the reports which were published by the Duinker group?

A Yes, some of those things came in the reports.

Q The components that were being worked with had ferrite pieces and glass foil between the ferrite pieces, did they not?

A Yes, sir.

Q Is it pretty much as I have drawn here, let us call this in Illustration 1? This is one ferrite piece, the opposing ferrite piece, and with glass foil, I should say, is that correct?

A Yes, the glass foil was of an undefined shape except for the thickness.

Q I think you explained in your direct examination that some of the foil may have had a curve to it,it all wasn't perfectly flat.

A Yes, sir.

THE COURT: When you started with the process was the laboratory using 8C1 ferrite?

THE WITNESS: At about that time we also started to use 8C1 ferrite, which was an industrialized ferrite you could then make on larger scale following the experimental ferrites which Duinker had used.

THE COURT: When you came to the laboratory you said that they were using glass foil to attempt to bond the ferrite, is that correct?

THE WITNESS: Yes, your Honor.

THE COURT: When you came to the laboratory were they already using shims or did they come later?

THE WITNESS: I do not recall in detail. To my recollection, efforts were made with and without shims

at approximately the same time.

Q This was information that was available there at the time you joined this section, so this information was not original with you, so to speak, it had already been in existence and people were using this information.

A Yes, sir.

Q Do you know of your own knowledge whether you or anyone in your group have undertaken any search of the literature or prior art to investigate the existing techniques for flowing glass into small spaces at or about the time you joined the project?

A I don't know whether we did that, sir.

Q From that I can assume at least no one told you that there were known techniques and you ought to consider it or you need not consider it, you simply don't know.

A I simply don't know.

Q I think you also testified that in 1961 this project, which I will call the Duinker project in order to use a shorthand label, because we move from the Duinker project to other modifications and so forth, but this is, as far as we are concerned, the original Duinker technique, and in 1961, when you joined this section, I believe you testified that the project was still in the experimental

or developmental stage. I believe that was your expression.

A Yes, sir.

Q The patent application, the Duinker patent application, was filed in Holland in October 1955, so that this is approximately six years later when you are assigned to this project.

A Yes, sir.

Q And it is still in the developmental stage. As far as you know personally, Mr. Vrolijks, was there any demand for a glass-bonded ferrite between the years 1955 and 1961?

A Yes, there was much interest as recordings went to higher frequencies.

Q I am asking you now, sir, of your own knowledge, do you know whether there was any demand for a glass-bonded ferrite during the interim between 1955 and 1961?

A About the interim I cannot give exact information for I was not involved in that period.

Q Did you consider the process or the technique as you observed it when you joined this laboratory impractical?

A Yes, sir.

Q I believe in your direct examination you used the word optimizing in connection with the Duinker

procedure and I believe you indicated that your assignment was to optimize the Duinker procedure.

Do you recall when you first began to work on optimizing the Duinker procedure? You were assigned to this section I believe in 1961. Do you recall whether it was towards the Christmas season or was it in the summer-time of '61?

A No, it was in the -- around the summer season I think, maybe somewhat earlier. It was my job to get the thing moving and maybe I have sometimes used the word optimizing for that.

Q I was going to ask you what you meant by using the word optimizing. Is that what you meant, you were going to get this project moving?

A Yes. When I started we continued to move along the lines as you gave there and then we started to optimize and besides that we started to find other ways to achieve similar results.

Q Before we get to that, when you indicate that part of your responsibility or part of your job was to get this project moving, that implies to me that the project was pretty much dormant until you were assigned to it and now your job was to get it moving in the right direction. Is that correct?

A No, it is not correct. It was not dormant, but there did not come good product out of it.

Q In your discussion in direct examination you used that model which I think is PX 171. I would like to refer to that, if I may, because it is very graphic.

A You want to have it, sir?

Q No, I would like you to use it because I would like to go with you in what was being done. If you hold it up a little bit, on the ledge, that lower part, what is that called, Mr. Vrolijks, what number?

A 171-B.

Q And the other?

A 171-A.

Q So that 171-A would be the upper piece and 171-B the lower piece, is that correct?

A That is correct.

Q This is the sort of thing that was there when you were assigned to the project. Then I believe you testified that Duinker also suggested the use of shims.

A Yes, sir.

Q And these shims were located at the end of 171 --

A D.

Q The shims are 171-D but they are resting on 171-B, the lower ferrite piece, and they are located at the ends, the four corners, so to speak, and that is a Duinker contribution too, apparently, is it not? I mean, that is not something that you suggested, the use of shims.

A No. Duinker used the shims as stops when pushing out the -- squeezing out the excessive glass.

Q If I can draw that, that is one part, that is the other part, and Duinker has shims, is that right?

A Yes, sir.

Q That is Duinker too.

A We have the other view now?

Q Yes. This is PX 171-A and this is PX 171-B, right?

A Yes, sir.

MR. CALIMAFDE: Your Honor, the patent which describes and covers the shims is in the prior art book as DX-K.

Q What I want to do here in this discussion with you, Mr. Vrolijks, is to get to the point precisely where you begin to contribute something. Right now we are still at the point where the information is prior to any contribution you have made, so that Duinker starts with the

technique, and at least that is disclosed in the patent in dispute, now Duinker puts in shims and Philips get a patent on the shims.

These shims are presumably equal to the gap length, are they not?

A Yes, they are essentially equal to the gap length.

Q So that the glass must be of a greater height than the shim height.

A Yes.

Q Because the glass is going to be lower when it is softened or melted.

A Yes, squeezed out.

THE COURT: Squeezed out is a better word I guess.

MR. CALIMAFDE: Perhaps, your Honor. In any event, it is reduced in height.

Q These shims, the shim height is critical, is it not, Mr. Vrolijks?

A Yes, sir.

Q Because it is the shim height which determines the gap length that we have been -- to use the expression, we have been using.

A That is true.

Q The equality is of such criticality that it must be within a few percent of the -- let me break that down.

In your view, at least as expressed in another subsequent patent, the shim height or the equality of the shim height is a critical consideration in making a glass-bonded ferrite core, is it not?

A Yes, sir.

Q All of this is still knowledge prior to your involvement or prior to anything you contributed.

A Yes, sir.

Q The idea of slicing when you place the 171-A on top of 171B, we now produce what looks like a loaf -- if you will do that for me, sir.

A Yes, sir.

Q The idea of slicing that lengthwise and then crosswise was also Duinker's idea, was it not?

A Yes, I think he did that too.

MR. CALIMAFDE: In fact, your Honor, they got another patent on that and that is DX-J in the prior art book.

Q I would have difficulty showing that, but in any event --

MR. RELSON: Your Honor, I have an objection

* * *

edge and you get another patent on that?

A But the process is completely different. One is squeezing out and the other is sucking in.

Q Let's discuss how different these two processes are.

THE COURT: Is there any capillary action involved in the Visser patent?

THE WITNESS: No, sir.

MR. CALIMAFDE: You anticipated me, your Honor. Let us find out whether there was or was not.

Q Perhaps the way to start, Mr. Vrolijks, is by beginning with Duinker again for just a moment, the Duinker patent, which is Plaintiff's Exhibit 141.

Perhaps before we start we ought to understand what is meant by "capillary."

If in Duinker the glass foil, and as I understand glass foil there, you had broken pieces of glass from some tube and they were placed on the bottom ferrite?

A The bars, yes.

Q If the glass foil were melted and assuming a very light pressure or perhaps just the weight of the other ferrite piece, but if that glass foil were melted, would the glass flow by capillary action to fill the gap?

A No, I don't think so. It had no freedom to do so

for a couple of reasons. It was mor softened than melted.

Q That is not my question.

Assuming the glass foil was melted so it was free to flow, isn't it a fact the glass would have flowed by capillary action to fill the gap fully?

A No, sir, I don't think so, for I think you still would have the problem of trapped air as the glass did not come from one side.

Q Let's exclude the trapped air because the trapped air would occur where the glass pieces came together, but where the glass pieces melted and flowed, the flowing process was due to capillary, was it not?

A I don't think so.

MR. RELSON: Objection.

THE COURT: He answered the question. He does not think so and at this point the Court does not either, but that may be secondary to counsel's consideration.

Q I don't want to belabor the point, Mr. Vrolijks, but if we visualize glass which does not fully occupy the entire surface area, so you have broken pieces of glass; if the glass simply melted and did not flow, you would have unoccupied regions within that gap, would you not?

A Yes. They were occupied by air.

Q Hear me out for just a moment more.

* * *

A We reduced the pressure that had to be used considerably.

Q You mean over the Duinker process as practiced rather than the Duinker process as illustrated in figure 1?

A The Duinker process as we applied it and the Visser method.

Q In the Duinker process as you partially used it at N.V. Philips, you merely softened the glass, you did not melt it?

A That is right.

Q Let's talk about the Visser process. Do you still have that Visser patent in front of you, Exhibit 248?

In your capillary process -- I said Visser, but let me establish one more reference point with you with regard to your capillary process.

About howmuch weight is placed on the upper pieces, the upper ferrite piece?

A In which process?

Q Yours, the Peloschek patent.

A I do not recall exactly. Some kilograms we placed on a block on a bar as described previously.

Q Let's consider the Visser/Vrolijks process where the rod is inside and let's assume, Mr. Vrolijks, you applied just that same amount of pressure that you applied in the

* * *

Q And in figure 4, could we define the fillet, I think shown at 10, the excess glass, which is described about line -- what looks like 52, the volume of each glass rod is larger than the volume of the ultimately desired gap. A quantity of excess glass will be formed and this excess glass after solidification appears for the greater part on the inside of the gap designated by the reference numeral 10, and they talk about what the excess contributes.

Do you find that?

A Yes.

Q For that excess glass to form a fillet, the temperature must have been at the melting point or above the melting point, isn't that correct?

A Yes, but the fillet does not have necessarily to be in the form as in this case. It may just occur as a very small part of glass, a couple of times thicker than the gap in the area of the gap.

Q Was this process the Visser process, one in which you describe the amount of pressure as being high to the point where it might damage the ferrite, or was that only in connection with the Duinker technique?

A To my recollection, it was in connection with the Duinker technique, where the Duinker technique, our usage of the Duinker technique with the shims.

* * *

2 Q So it is not yet at 600 degrees, it is rising
3 very sharply, vertically?
4 A The expansion is rising sharply.
5 Q Soon that expansion is going to turn around and
6 become completely liquid, is it not?
7 A It is not yet completely liquid.
8 Q That is right. At what point would you judge
9 from this curve that it becomes completely liquid?
10 A I am sorry, that I do not know.
11 Q The curve does not show it but in your experience,
12 Mr. Vrolijks, can you say somewhere probably around 7,
13 800 degrees, it will be completely liquid from the vertical
14 rise shown before 600 degrees?
15 A I think that this glass with this composition
16 and high silicone oxide content will have a very long melting
17 range, so where it becomes completely liquid, I really
18 don't know.
19 Q And you cannot, from your experience, judge from
20 looking at the steepness of the vertical rise at where it is
21 going to turn around and become completely liquid?
22 A No, I am not familiar with those curves, really
23 familiar.
24 Q You indicated in connection with your capillary
25 process that capillary requires wetting, is that correct?

A That is correct.

Q I believe you also testified when this subject came up between you and Mr. Peloschek, that one of the considerations was whether or not ferrite wets; is that correct?

A Yes, sufficiently to provide the possibility that this small space will be filled.

Q The capillary formular which is Plaintiff's Exhibit 172 provides us with information with regard to the space to be filled and with regard to a meniscus angle.

A Yes, sir.

Q That tells us what conditions must be fulfilled in order to have capillary action, does it not?

A Yes, sir. It shows that.

Q You would know the viscosity of a melted glass?

A Yes.

Q What other conditions? You know the space that you want to fill, the gap you want to fill?

A Yes.

Q And you know the meniscus angle.

A I didn't know that.

Q The Duinker patent gives you a broader idea, but that is something that could be measured anyway, the meniscus angle?

A Yes, I assume so.

Q As I see it --

THE COURT: Don't testify for him. He said he, he assumes so. You said yes. If you want to ask a question, ask it, but that will not help me when I search the record.

MR. CALIMAFDE: Right, sir.

Q You say yes, you assume so. You assume that the meniscus angle for glass on ferrite can be determined, is that what you mean?

A Yes.

Q Are there any factors in this formula which have not been or could not have been fulfilled which would have predicted for you the suitability of the capillary process in flowing the glass?

A I think the wetting is a very important point. We thought that the very small space to be filled and the large depth, those were difficult points.

Q The depth is the "H" in the formula of PX 172, is it not?

A It is not comparable for reflow horizontally.

Q If you flow horizontally and vertically, you will assume you will get the same distance shown by the letter "H" in Exhibit 172?

A That is not true.

Q The capillary does not recognize the difference in

horizontal or vertical travel of the fluid in the gap space, does it?

A Yes, it does.

Q So that is it your testimony, Mr. Vrolijks, that one of the conditions which you wanted satisfied was whether the capillary would flow horizontally by capillary?

A Could you repeat that question?

Q Let me rephrase it.

Was one of the considerations which you wished to have satisfied was whether the glass could be made to flow horizontally by capillary?

A Yes. In this set up.

Q In this set up. This set up provides a gap of a given dimension.

A That is correct.

Q That gap dimension is in a capillary formula?

A Yes. That is a tube in this case and in our case it was not a tube, but a channel.

Q But you knew, did you not, capillary would flow into a channel or a gap?

A Yes. In principal, I know.

Q You knew or you could determine the viscosity of a melted glass which was going to be flowed into the gap?

A That could be determined and what we knew was that

this was generally much thicker than let's say water and other thin viscous materials which you flow easily into capillary tubes.

Q You simply melt it and you found out whether it worked? You put the rod at the edges of the gap, you melted it and you observed whether it would flow by capillary?

MR. RELSON: Which question does he want the witness to answer?

MR. CALIMAFDE: I asked only one question.

THE COURT: If you understand the question. I have difficulty with it, also.

MR. CALIMAFDE: Let me rephrase it.

Q You weren't certain, you testified, as to whether you could make this glass flow into the gap or the space?

A That is correct.

Q So you set up the arrangement, you set up your ferrite core with the gap and you placed the glass rod at the edge of the gap and subjected it to a melting temperature and you observed whether or not it would work.

A That is what we did after various experiments, yes.

Q When you talk about experiments, experiments with capillary or experiments with other materials or processes?

A Experiments with capillary.

Q Was your first experiment simply arranging the ferrite pieces with the desired gap and placing the glass rod at the edge of the gap?

A No. In the first experiments we placed some powder at the edge of the gap and we, Visser, placed the shims in the G position so the whole assembly was clamped then we made our first experiment.

THE COURT: That was the so-called glass powder emulsion that you testified about?

THE WITNESS: No, your Honor. This was simply powdered glass without any organic binder or similar materials with it.

THE COURT: That was after you had used the flat foil?

THE WITNESS: Yes, your Honor.

THE COURT: Let me see if I am clear.

When you came to the project, flat foil was used, was it not?

THE WITNESS: Yes, your Honor.

THE COURT: Thereafter, this powdered glass was used?

THE WITNESS: This powdered glass was used parallel as one of the efforts, one of the other efforts to produce glass gaps.

THE COURT: Then you moved to the emulsion, the glass-powdered emulsion that I just asked you about?

THE WITNESS: I thought that was what you meant just when you said the powder.

THE COURT: Yes. I seem to be confused here and I would like to get myself straightened out.

THE WITNESS: A number of these things went parallel, of course, so that of course is a difficult problem.

THE COURT: Would you just step by step tell us the different things that you tried relative to the use of glass in various forms?

THE WITNESS: We can go out from the starting point where glass foil was used. Simply and only consisting of glass, blown-out foil. Other steps to produce glass gaps, and there are not necessarily in the G sequence as I quote them to you, are this glass ribbon which we discussed, the glass powder made as an emulsion with organic binder and transferred in this way to glass foil, but that is not a pure foil, that is a glass foil with organic binder with it. That had to be placed on the ferrite bars and the binder has to be burned out before the gap could be made.

Also, then the glass rod as described there on the blackboard and another one was the capillary method where we used in the first experiment or experiments glass powder,

but again, only consisting of glass so no organic carrier or material with it and that was placed not in the gap but adjacent to the gap.

THE COURT: And lastly, you had the glass rods which were placed adjacent to the gap?

THE WITNESS: Yes.

THE COURT: And that is what you ultimately patented?

THE WITNESS: We patented also the glass powder for that work but in our opinion, the glass rod was the most optimal way to do it.

Q Mr. Vrolijks, what I would like to understand with you is precisely what you knew with regard to capillary and what you believed you had to determine before you could apply the capillary process to the flowing of glass into the gap.

You knew that capillary was an old process for flowing liquids into spaces in gaps, did you not?

A I knew that capillary phenomena existed. I did not know whether it was used in production techniques.

Q You knew of capillary as a process for flowing a fluid or a liquid into a small space?

A Yes.

Q And you knew the conditions that would have to be

satisfied in order to make the glass flow into this gap?

A I don't think we thought so much about that. At least in analyzing all the pros and cons.

Q You knew there was a formula that would determine whether fluid could flow by capillary and the height or the length of flow by the fluid, that formula as shown on that exhibit?

A Yes. I had certainly learned that formula somewheres.

Q In your discussions with Peloschek with regard to the problems of the Duinker technique, what made you or Peloschek consider the capillary technique?

A I really do not recall in detail the importance in the whole discussion we had together. The emphasis came on that the materials should come from one side and not be there previously. That was an important part in how we were going to solve this technological problem we had.

Q Do I understand the word "material" to be glass?

A That is correct.

Q So you and Peolschek decided that the glass material should come in afrom an edge rather than be placed in the middle of the space, is that correct?

A That is correct.

Q Was Peloschek aware of your work with Visser?

A Yes.

put together. Some years ago we brought an oven into a courtroom in New Jersey and demonstrated how a glass to metal seal was made before Judge Shaw.

I will look into that and if we can come up with something that is meaningful we shall, your Honor.

THE COURT: I will be more than willing to take the testimony of the respective experts.

Q In this PX 172, which is the capillary illustration, including the capillary formula, you indicated that the formula showed capillary rising in a vertical direction.

A Yes, sir.

Q And there was a question in your mind as to whether it can be made to flow in a horizontal direction at the time that you were considering capillary.

A This particular situation where we had a gap of four microns, which is what, 160 microinches, to fill over -- let's stay with the four microns -- over a very large depth, a thousand times as large. We wanted to fill four millimeters and a width of 25 millimeters or 6,000 times as large. We all wanted that that would happen in one continuous stream, so that no air would be included somewhere, would be trapped. We were not sure whether that would work.

Q Mr. Vrolijks, if you place the glass at the

edge of the gap and that glass is made to melt it will obviously flow into the gap by capillary.

A It will flow into the gap if the wetting is good, if the surface --

Q I understand that. Assuming it wets and assuming that the glass will be melted to a temperature high enough to cause it to become liquid --

A Sufficiently liquid for this very minute gap where it had to go in.

Q Doesn't capillary flow require that the gap be very minute?

A Yes, but this is so minute -- I mean, if you draw just normal -- like people who draw capillaries. they are much larger than the four microns and two microns we are talking about here.

Q According to the formula the narrower the gap the more or the greater distance the liquid will flow by capillary.

A Yes, that is true. But still it has to go in.

Q If we place the glass at the edge of the gap, and assuming it is going to flow into the gap, doesn't it follow it is going to push any air that is in the gap away or out of the gap as the glass is flowing in its path?

A Yes, but the important point in this whole process is that it flows all together, for if there would be some difference in speed then easily air could be trapped in between.

I don't know whether you understand what I mean.

Q Yes, I do. You are talking about a wave-front that may not be completely in line as it is moving through the gap, that the wave-front may have a depression.

A If it has a depression and then it goes -- on the sides it goes quicker it can easily trap air.

Q What you are saying is that as the wave-front goes through the gap the forward part of the wave will reach the edge of the gap before the center part but as it continues through the gap it will flow out the other side, will it not, and that is what you grind out later, grind away later?

A There comes some glass through the gaps and you can notice that on the other side.

Q The only point I wanted to make in regard to this Exhibit 172 was that I thought I understood you this morning to say that this illustration shows the capillary rising in a vertical direction whereas your use of the capillary was going to be in the horizontal

* * *

with National Micronetics closely specified M-210 material and bonding glass," and I emphasize what follows, "Insure maximum part to part magnetic and dimensional uniformity and mechanical strength."

Does that signify to you, for example, that this part was made with materials which had matching expansion characteristics, when they say "maximum part to part magnetic and dimensional uniformity and mechanical strength"?

THE WITNESS: It may suggest something like that, but it is not --

THE COURT: It is not clearly stated.

THE WITNESS: No. Then you have to know all the specifications from Micronetics.

Q In fact, that same statement could apply to a core in which the CTE's are mismatched, isn't that true?

A That depends on the specified material and bonding glass.

Q So you simply can't tell from looking at this?

A No, I can't.

Q Did I understand your testimony in direct that the capillary process was the only commercial process used at N.V. Philips?

A I don't think I said that.

Q That is not the fact, is it, sir?

A That is not the fact.

Q In fact, the Visser process was used commercially for a period of time before the capillary process was used, isn't that true?

A I think we started the Visser process in pilot production, but it was superseded, taken over by the capillary action method.

Q Do you still have your transcript of deposition in front of you?

A Yes, sir.

Q Would you turn to page 93, please, line 16.

MR. CALIMAFDE: Your Honor, in this deposition reference is made to an Exhibit 2, Exhibit 2 is the Visser patent.

Q I will ask you, Mr. Vrolijks, were not the following questions put to you and did you not make the following answers:

"Question: Was the process as suggested by your Exhibit 2" -- that's the Visser patent -- "ever used commercially by N.V. Philips?

"Answer: The production group started to use this method.

"Question: 'This" being your Exhibit 2 method.

"Answer: Yes, but later it was followed by the exhibit --

"Question: The capillary method?

"Answer: The capillary method.

"Question: How much later?

"Answer: That I don't recall.

"Question: A couple of years or a couple of months?

"Answer: I don't think it was a couple of years. It was less than a couple of years. About how much less I cannot recall. It is about twelve years ago or something. And so --

"Question: Let's use one year as a yardstick. Was it more or less than one year? You have no feel for it?

"Answer: No.

"Question: You do recall that a certain quantity of glass-bonded ferrite heads made by the technique of your Exhibit 2 were made and sold commercially that way, were made that way and sold commercially, I should say?

"Answer: Yes.

"Question: Following that technique N.V.

Philips went to the capillary technique.

"Answer: Yes, that is right.

"Question: Was there an imtermediary technique or did it go from your Exhibit 2 technique directly to the capillary technique?

"Answer: Yes, the Exhibit 2 technique was followed by the capillary technique."

Did you not make those answers to those questions?

A I made those answers, yes.

Q Did the core which was made by the rod technique have the same appearance as the core made by the capillary technique?

A No, it had not.

Q Can you tell us in a general way how they differed or did they differ in any significant respect, did they have the same outward configuration?

A You could make them with the same outward configuration. We made different configurations.

Q You did make different configurations?

A Yes, sir. This would be one.

Q Some mention was made in your direct examination about the grinding and machining operations of the core after the glass was bonded.

* * *

rklt 2

the following exhibits, 57, 57A, 58, 58A, 60, 66, 109, 1110 and 113. These were produced at different times and hence the different numbers.

I will offer them collectively.

MR. CALIMAFDE: No objection.

THE COURT: Received.

(Plaintiff's Exhibit 57, 57A, 58, 58A, 60, 66, 109, 110, 111, and 113 were received in evidence.)

MR. RELSON: Did your Honor want to run through these casually?

THE COURT: No. I will let you develop them and I will understand their significance better when I hear the testimony that you expect to present. The description is already contained in the pretrial order so I don't think I could get much more than that.

MR. RELSON: I call Mr. Rivelli.

P A T R I C K A. R I V E L L I, called as a witness on benalf of the plaintiff, being first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. RELSON:

Q Mr. Rivelli, by whom are you employed?

A National Micronetics.

Q In what capacity?

A I am a vice president.

Q Are you a stockholder?

A Yes, I am.

Q Are you a director?

A Yes, I am.

Q Are you one of the founders of the company?

A Yes, I am.

Q Were you previously employed at Ferroxcube Corporation?

A Yes, I was previously employed at Ferroxcube Corporation.

Q In what capacity?

A I was manager of Computer Components Division, a division which had nothing to do with the subject matter in question.

Q For what period of time?

A For approximately a year and a half to two years.

MR. RELSON: Your Honor, we took some extensive depositions of Mr.Rivelli and in the interest of cutting the trial time short, we propose to rely largely on those depositions. I want to go into a couple of points with Mr. Rivelli here to supplement what was in the depositions and I will try to keep it brief.

Q Mr. Rivelli, I understand that you were at one time

* * *

peaked, as you testified with respect to the 2314?

A To the best of my knowledge, no. As a matter of fact, in my market studies it is a possibility that the 3330, depending on the industry, may not have seen its peak yet. But there are still significant sales of that product. IBM, to the best of my knowledge, is still producing that machine.

Q From your market studies what portion of the glass-bonded core production is accomplished by IBM?

A I would say better than seventy percent.

Q And that leaves thirty percent for the other core manufacturers, such as Micronetics and Ferroxcube and possibly others?

A And other manufacturers of the equipment itself who make their own cores, their own ferrite and their own cores inhouse.

Q Excluding the inhouse core manufacturers and considering the market for cores sold to others, such as Micronetics does, approximately what percentage of the total glass-bonded core production does that include?

A I would offer an estimate of twenty percent. More than have could -- to the best of my latest information, is coming from Japan these days.

Q Twenty percent out of the thirty percent you mentioned?

A No. I'm sorry. I am saying that seventy percent is IBM, Probably another 10 percent by equipment manufacturers who make their heads inhouse and their cores inhouse, and the other twenty percent by the core manufacturers, including U.S. and Japanese sources, and half of this twenty percent I am estimating is coming from Japan.

Q Currently, is that it?

A Yes, to the best of my knowledge.

Q Has that been a recent development in the field?

A It has fluctuated over the past years.

Q So that leave about ten percent for domestic core manufacturers, right?

A The best way I can envision it, yes.

Q From your market studies what part of that ten percent does Micronetics satisfy?

A At the present time, sir?

Q Take the present time and then we will see what the situation has been over the past several years.

MR. CALIMAFDE: Your Honor, may I ask the relevancy of this question?

MR. RELSON: I think this goes to the quesion of the commercial use of the patented product and the extent of use of the patented process by this limited segment of core manufacturers.

THE COURT: I can see that on the question of damages, but we haven't gotten to damages and I do not expect to treat with that at this trial. I think counsel would be willing to stipulate that his client manufactures ferrite cores for commercial sale and has done so for the last five years.

MR. CALIMAFDE: We don't dispute that, your Honor, and it hasn't been established by Mr. Relson that the ferrite cores about which this man is talking uses matched CTE's.

MR. RELSON: That is part of our forthcoming case.

THE COURT: All right.

MR. CALIMAFDE: We are talking about the ten percent of Micronetics, ten percent perhaps, marketing in the industry, and yet I think the witness has testified that ninety percent of their manufacture offers these two glasses, the 2205 and the 2104, which have mismatched CTE's.

THE COURT: I am not going to try to interfere with Mr. Relson's presentation at this point. I am going to let him develop this. But I think we can move it along. This has been slow and somewhat strung out, where I think the basic bottom line issue in this area of inquiry is a practically stipulated matter.

But I will let you develop it in your own way.

Mr. Relson has indicated that you have from the total of ferrite cores produced worldwide some remaining ten percent of ferrite cores and in that market Micronetics shares.

THE WITNESS: Yes, your Honor.

THE COURT: Am I correct?

THE WITNESS: Yes, your Honor.

THE COURT: In what percentage do you sahre in that ten percent remaining market?

THE WITNESS: I would say currently somewhere between two and a half and five percent of that remaining ten.

THE COURT: A quarter to a half of it ?

THE WITNESS: Yes,your Honor. I am not exactly sure where in there it lies.

Q Just one final question on this point:

Does Ferroxcube supply a substantial part of the remainder, from your market studies?

A From my market studies, Ferroxcube is a major supplier of glass-bonded recording head cores.

THE COURT: Can you tell us from what your market studies reveal what portion of the ten percent Ferroxcube has at the present time?

THE WITNESS: I would say at least five percent, your Honor. I mean -- yes, at least half of the ten percent.

Q Just to conclude, Ferroxcube and Micronetics

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between them cover substantially all of the domestic production of cores by the independent core manufacturers, excluding the Japanese?

A There are some others. Their production is small, perhaps some fraction of one percent. Yes.

MR. RELSON: I offer for identification only at this time, a chart marked Exhibit 170, entitled "Glass-Bonded Core Manufacturing."

(Plaintiff's Exhibit 170 was marked for identification.)

MR. RELSON: Your Honor has a copy in the exhibit book.

THE COURT: Do you have anything else of this witness?

MR. RELSON: Yes, your Honor. I am going through this exhibit with him, which will indicate the process of manufacturing.

THE COURT: All right.

Q I show you Exhibit 170, Mr. Rivelli, and I propose to take you through the Micronetics process step by step, using this exhibit as a way of focusing on the individual steps.

You will see under heading A a legend Ferrite Brick, and then under B and B Prime, the designation Slab.

* * *

rkjw 11 Rivelli - direct

Q Necessarily it does?

A Yes.

Q Upon cooling, the glass has filled the gap and bonds the ferrite parts together, right?

A Yes.

Q After cutting the bars --

THE COURT: Do you also have a resulting fillet of glass?

THE WITNESS: Yes, your Honor, we have a fillet in the apex area.

Q Is that fillet accomplished automatically by this process?

A Yes, it is. There is no secondary bonding.

Q Excuse me, I didn't hear the last phrase.

A There is no secondary bonding or glassing operation.

Q Is that fillet a necessary consequence of the process that you follow?

A I believe it adds to the strength of the part.

Q That wasn't the question.

MR. RELSON: Would you read it back?

(Record read)

THE COURT: Isn't that the same question in

another form?

MR. RELSON: No, your Honor.

Q What I am really saying is you can't avoid having that fillet by the process you use, is that right?

THE COURT: In any event, when the process is completed, the fillet is there.

A When the process is completed, the fillet is there. We use a glass of sufficient size so there is a fillet there. If we used a very much smaller rod, we would perhaps use the gap but have no fillet, thereby having a somewhat weaker core resulting.

THE COURT: If you had a larger glass rod, am I correct that you would have a larger fillet?

THE WITNESS: Yes, your Honor, up to the point where it started to flow all over the place.

THE COURT: So the size of the fillet is dependent on the size of the glass rod? In essence, it is how much material is left over after the glass rod melts and the gap is filled?

THE WITNESS: Yes, your Honor, exactly.

Q After the bonding operation is completed and the bar is cooled and you have sliced the bar to form the individual core pieces you then grind and polish those pieces to individual dimension, do you not?

* * *

special core for this one and a special core for that one.

Q Just coming back to the exact question, it is correct, is it not, that the customers' tolerance range was 20 micro inches on either side of the nominal in those cases?

A The customers' tolerance range, yes.

Q Let me go back to the 3330. Is it correct that the customers' tolerance range was 10 micro inches on either side of the nominal value of 100 micro inches?

A Yes, sir.

Q So the customers in one case wanted gap lengths between 90 and 110 for the 3330 and in the other case wanted gap lengths between 85 and 125 for the 2314, is that correct?

A Not exactly, sir. Some customers wanted ranges from 85 to 115, others wanted them from 90 to whatever, 120.

Q Yes, but there were certain ones who wanted 85 to 125, isn't that correct?

A That's what they -- well, I don't know of any, sir, that wanted a range from 85 to 125, to my recollection.

Q From 80 to 120 then.

A From 85 to 115. I remember you showed me a drawing this morning from 80 to 120.

Q So the desired gap length that the customers wanted was within that tolerance range, was it not?

A That's what they would accept, yes.

* * *

DIRECT EXAMINATION

BY MR. RELSON:

Q By whom are you employed, Mr. Robinson?

A Ferroxcube Corporation.

Q What capacity?

A Vice-president and general manager.

Q Would you state in a very general way when you joined Ferroxcube and the positions you have held up to the present time?

A Yes, I joined Ferroxcube in January of 1966. I initially came on board as a director of planning. Approximately 1967 I took over marketing responsibility along with planning for the area of recording products, including cores.

Then in 1968, that was divisionalized. I became the general manager of the magnetic products division, which included the cores and recording heads.

In 1969 they joined with that division a second division of linear ferrites then in 1972 I assumed responsibility for the corporation as it stands today.

Q Were you acquainted with Ned W. Buoymaster during your career at Ferroxcube?

A Yes. I was hired by Mr. Buoymaster and was well acquainted with him up to the period he left, I believe

* * *

to the potential users of our products in this glass-bonded ferrite field?

A Yes. We continuously attempt to keep abreast of the marketplace, gathering data on what has occurred what we know of in the past and projecting what we feel will happen in the future by specific categories.

Q Did you hear Mr. Rivelli's testimony today concerning the portion of the market in various categories?

A Yes.

Q Would you give us your views as to the portion of the glass-bonded ferrite core market which is produced by IBM?

A I differ to a limited degree in that we feel -- we separate the market from captive and non-captive. The captive being that portion where a manufacturer that uses glass-bonded cores makes themselves. The case in point IBM.

We feel that the IBM in the peripheral area has approximately 60 percent of the market, not 70 as indicated by Mr. Rivelli, and that approximately of the remainder, fifteen to twenty percent of that would be available to people such as ourselves, Micronetics and Ferroxcube.

We have felt in our assessment of the

competitive position that Micronetics beginning in late 1969, 1970, with approximately 40 percent of the market, we being, that is, Ferroxcube being 40 and the remaining 20 percent split up among a number of other competitors.

Q Are you referring now to the non-captive market?

THE COURT: The 15 to 20 percent that was available which would be split 40-40 between two companies and 20 percent to the remaining people working in the field.

THE WITNESS: That is correct.

Q What time frame are you referring to in connection with those figures?

A As indicated, they are starting in, I would say, 1970, 1971, that market share would have been achieved.

Q Does it continue today?

A We feel possibly we would have a slightly larger share today than they would. Possibly we might have close to 50 percent, their having 35 at this point, is my best estimate.

Q Did you at my request make up a table of Ferroxcube sales of glass-bonded ferrite recording structures?

A Yes.

* * *

Q When your attorney made his proffer of proof I believe you were in the courtroom and you may recall that this exhibit was initially objected to and your attorney made a proffer of proof, what he expected to prove by this, and one of the things I noted that he said was that that exhibit would show that when Micronetics entered the field it caused a reduction in sales by Ferroxcube.

Do you accept that, first of all, Mr. Robinson, that when Micronetics entered the field that it caused a reduction in sales of pole pieces by Ferroxcube?

A Oh, quite definitely. For more than a year and a half we were the only firm in the United States that could manufacture the 2314 type pole pieces.

Q Would you take Exhibit 213, which is --

THE COURT: That is, outside of IBM.

THE WITNESS: Yes, sir. I am sorry.

Q Would you take Exhibit 213 and hold that alongside of Exhibit 212. If you would look at the Micronetics figures on 213, which are for -- I am not sure it is of record yet, but these are for cores, glass-bonded ferrite cores, for the most part, anyway.

If you look at the year '69, that is the year when Micronetics entered the field, Micronetics had sales of $81,000 and Ferroxcube had $1,347,000.

* * *

that we have a license under the patents that were discussed here, because I signed an agreement recognizing that we were building them under these patents, that I would pay royalties only after -- only at such time as the chief competition did so, or else I would be placed at a competitive disadvantage in the field.

Q So that Ferroxcube has not paid any royalties to date under these two patents in suit?

A Only except as should be noted, that I continuously pay each month technical assistance and royalties for know-how, et cetera, to N.V. Philips, constantly pay that.

Q Under the package of technical know-how?

A According to my understanding, it gives me the right to produce products developed by them and also to ask for technical assistance in setting up my own manufacturing. That's the payment that I make continuously.

And I do, as a result of this, travel frequently to Philips, and my engineering people do as well, and they in return come to us.

Q Have you been requested by U.S. Philips to take a license under the patents in suit?

A Yes.

Q Do I understand your answer that you have

* * *

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WILLIAM C. LA COURSE,

called as a witness by the plaintiffs, being first duly sworn, testified as follows:

THE COURT: Do you have a biographical background of the witness, as you had with Mr. Kornei?

MR. RELSON: No, sir. I am sorry, I did not.

THE COURT: All right. I just thought we could save some time.

DIRECT EXAMINATION

BY MR. RELSON:

Q Dr. LaCourse, would you state your residence.

A 94 South Main Street, Alfred, New York.

Q What is your occupation?

A I am an assistant professor of glass science in the New York State College of Ceramics at Alfred University.

Q Would you state your college and post-college education?

A I obtained my BS degree in 1966 in engineering science from the SUNY at Stonybrook.

Q That is SUNY?

A Yes, State University of New York. I stayed there through the summer of 1967 and got my degree in materials science.

* * *

particular curve, perpendicular to this line, so it would just go simply straight down, as they have shown here.

Q How do you determine the elongation of the particular glass at the transformation temperature?

A Again, you would follow that same straight line until it intersects -- going upwards in this case -- until it intersects the actual expansion that the glass has gone through at that temperature, so you are increasing now -- you are following this line up directly until it intersects the expansion curve, and at that point would be the actual expansion of the glass at the transformation point.

Q What is meant by the working range of glass and what is its significance?

I will take one question at a time. What is meant by the working range of glass?

A The working range is a range of viscosity and therefore a range of temperatures, in which the glass is fluid enough to be generally formed into a shape by some manufacturing operation or hand-blowing operation and yet at least in the higher viscosity portion not so viscous that it will completely lose the shape immediately after having obtained that shape, so you can form it or you can work with it, but it will retain that shape at least for a

period of time. If you were to leave it at that temperature the glass would simply go back into a blob or something else. But it does retain its shape for a certain length of time, which allows you to cool it to freeze it in the particular shape that you want.

THE COURT: So that when a glass blower takes his blower or pipe and dips it in and takes some what I will call molten glass it is in that state that you have just described, is it not?

THE WITNESS: Yes.

THE COURT: He then blows it into shape and if he leaves it to cool it will retain the shape, if he puts it back into greater heat it will resume the appearance of the blob that it was when he took it out?

Is that about the way it works?

THE WITNESS: That is correct. Part of the art of the glass blower is knowing what exact -- how much time to wait before he actually does the blowing so that it does retain the shape.

THE COURT: But he starts with a blob of material.

THE WITNESS: Yes, sir.

THE COURT: And his aim is to wind up with a material which will retain the shape into which he blows

it?

THE WITNESS: Yes, sir.

Q Would you state whether or not the working range is the range where common pressing operations are performed on glass in various manufacturing procedures .

A Yes.

Q The table before you indicated various viscosities for various points along the heating curve of glass, and I refer you also to Page 73, the top graph there.

The transformation point is indicated as ten to the 13.2 power as its viscosity value. What is the unit of viscosity?

A Poise.

Q Then ten to the 13.3 power would be equal to two times ten to the 13 power, is that correct?

A Yes, sir.

Q In general, that would be 20 million million, is that correct?

A Yes, sir, that is correct.

* * *

Q What is the viscosity of the glass in the working range?

A 10 to the 3rd to 10 to the 6th, 10 to the 7th poise. It is a range of viscosities, therefore a range of temperatures.

Q That would be from a thousand to a million or ten million, is that it?

A Yes.

Q From there?

A The melting region or the melting temperatures, that temperature approximately where the glass has a viscosity of one hundred poise. It is fairly fluid at that temperature.

Q You say it is fairly fluid. Can you compare it with some very common materials to give an indication of the degree of fluidity?

A I believe water, the centipoise has twenty degrees centigrade. Water has a viscosity of one centipoise which is 1/100 of a poise so this glass is extremely more viscous than water.

Q Approximately how many times more viscous?

A Approximately 1,000 times.

THE COURT: You find a lesser number if you compared it with oil?

THE WITNESS: Yes.

* * *

Q Dr. LaCourse, are there limitations as to temperature in the use of glass in industrial processes?

A Yes.

Q What factors dictate such limitations?

A You have to have the lower temperature limit where the glass can be easily worked into the final shape you want it to be. The upper temperature is limited by many factors. You would like to avoid crystallization of the glass in general. You want it to remain as a non-crystaline material, which would indicate a low temperature. Chemical reactions, if the glass is in contact with anything else would be important.

You would want to avoid in general, which would change, perhaps, the composition of the glass, volitilization. Bubbles. Sometimes it is reboiled in the glass.

Q Is it or is it not fair to say that you would use the glass in such a process at the lowest temperature for which it would be effective?

A In general, that is true, for engineering conversations alone.

THE COURT: And time?

THE WITNESS: Excuse me?

THE COURT: And time in a production process, if the time is important. It takes longer to heat a substance

* * *

are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains."

So that the objection, your Honor, goes first to the point of time. This man is not a person skilled in the art at the time the alleged inventions were made, so he is incapable of giving an opinion as to what would have been obvious to a person skilled in the art at that time.

I think he is established as a person capable of running these tests and that is the extent of his skill as established in this courtroom.

THE COURT: Let me hear the question in its present form, unless, Mr. Relson, you wish to rephrase it.

MR. RELSON: I have a comment, if I might, on the objection, your Honor.

THE COURT: You may.

MR. RELSON: The ultimate issue which this Court will decide is essentially as phrased by Mr. Calimafde.

However, in our submission if the subject matter was not obvious after the time the invention was made I think it is highly probative as to whether it was

* * *

Peloschek.

THE COURT: I am not trying to make a suggestion. Just ask your question and I will listen carefully to it.

BY MR. RELSON:

Q Dr. LaCourse, excluding from consideration what you may know of the Peloschek patent here in suit and what you have learned in the course of this litigation, do you have an opinion as to whether or not it would have been obvious at any time since you entered the field, and I am suggesting that you entered the field at the time of your bachelor's degree, January 1966, obvious at that time to a person or ordinary skill in the art, as you know persons in the art, to bond two pieces of ferrite separated by a gap of the order of 100 microinches by means of glass inserted by capillary action?

MR. CALIMAFDE: In my opinion, your Honor, the question is objectionable, but I think it is of such low probative value that it is hardly worth --

THE COURT: I think it gets down in the final analysis -- we can play with the words some more, but it gets down to the weight to be given the witness' testimony, and I will do that in light of his educational background, his experience, his demeanor on the stand. The latter has impressed the Court. I will tell you that. But the

other factors obviously will fit into my consideration.

Let's have the question reread to the witness, and then if you would give us your opinion.

(Question read)

A I can say that with a small gap, assuming that the glass is of a viscosity within the working range, that it would not be obvious.

MR. CALIMAFDE: That was not a responsive answer, your Honor.

MR. RELSON: We will cover that.

MR. CALIMAFDE: I object to it. I move to strike the answer as being unresponsive. The witness put additional conditions on the question to make it practically unworkable.

Q If the temperature of the glass were at the melting point --

THE COURT: Just a moment. I am going to let the answer stand. I agree with you that its not completely responsive to the question, and it may be that counsel will want to inquire further.

THE WITNESS: Sorry.

Q If the temperature of the glass were at the melting point what would your answer be?

A It's possible at the melting point.

Q What is possible?

A That given enough time that the material -- someone would think that the material might go in at the melting point or above the melting point, at a low viscosity, very fluid.

Q Would it or would it not be possible above the melting point?

A I would consider above the melting point that it is possible that someone would think of doing it, because you have a very fluid material.

Q How fluid is it at the melting point?

A It's about, as we said, 100 to 1,000 times more viscous than water. And as I say, if it is less viscous than that, if you are approaching the fluidity of water, at that point you might think that capillary action would work.

THE COURT: Mr. Calimafde, you made several objections over the last few minutes. Do you wish to restate any of them at this time or do you wish to withdraw them?

MR. CALIMAFDE: I withdraw them, sir.

Q Have you in any of your reading or any of your studies come across a situation where glass was introduced into a minute gap by capillary action?

A No, sir, I have not.

Q Have you seen any suggestions of that sort in the literature or have you derived such from any persons?

A No, sir, not to my best recollection. I can never remember hearing anything of that nature.

THE COURT: Did you at any time engage in any research activity, alone or in conjunction with others, where you sought to do this?

THE WITNESS: Is this by capillary action your speaking?

THE COURT: Yes, introduce glass into a very small space by capillary action.

THE WITNESS: No, sir.

THE COURT: So you never tried to research the thing or were engaged in research on the subject?

THE WITNESS: No, sir.

Q In order to have the fluidity suitable for capillary action can you tell us how high in the range illustrated in Page 73 of Exhibit 180 the temperature would have to go? Look at the upper curve.

A The temperature is -- I don't believe its listed, but I think we would have to extend the viscosity curve beyond where it is. In other words, it would have

to be extremely fluid.

Q Would that be substantially above the melting point?

A Well, in terms of temperature -- the viscosity would have to be less than at the melting point. In terms of temperature, that depends on what glass you are working with.

Q Would you state whether or not that viscosity would be attainable at the melting point?

A Are you speaking of the melting point that is mentioned in this curve?

Q Yes, sir.

A I would not think so. I said above that point.

Q What viscosity values did you have in mind when you were considering that glass could be flowed into such a minute gap?

A I said -- I believe I said that I was approaching that of water, which is approximately 1,000 times less than that of the melting point as it is defined here, sir.

MR. RELSON: That is all, your Honor.

THE COURT: We will take a five minute recess.

MR. CALIMAFDE: Thank you, sir.

(Recess) * * *

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AFTERNOON SESSION

2 p.m.

THE COURT: Good afternoon, you may proceed, Mr. Relson.

L A R R Y A. W A N K, called as a witness on behalf of the plaintiff, being first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. RELSON:

Q Where do you reside, Mr. Wank?

A My home address is R.D. 1, Hunter, New York.

Q By whom are you employed?

A Ferroxcube Corporation.

Q In what capacity?

THE COURT: Keep your voice up, please, Mr. Wank. Ferroxcube and in what capacity?

A My present position is Engineering 2 and Manufacturing and Engineering Group.

Q What are your responsibilities in that position?

A Presently I have project responsibility for the prototype area of the new cores that we will be making. I also have project responsibility for a materials improvement program.

Q How long have you worked at Ferroxcube?

* * *

in the gap thickness that I was able to obtain, I increased the temperatures to be equal to that of the normal bonding temperatures.

Q In the experiment were your temperatures above the softening range of the glass?

A Yes, they were.

Q Were they in the melting range?

A At the end of my experimentation they were in the melting range, yes.

Q Do you have any indication of the viscosity of the glass that you achieved in this experiment?

A Yes. I would say that the viscosity at the end of experimentation was probably somewhere around 10 to the 2nd poise. At the beginning of the experiment the viscosity may have been as high as 10 to the 6th or 7th poise.

Q In the normal Ferroxcube production process, what is the approximate viscosity of the glass?

A The standard temperature that we are using now would indicate a value of around 10 to the 2nd poise.

Q That is 100 poise?

A That's correct.

Q Have you had experience with the use of glass temperatures in glass bonding at temperatures which would produce viscosities lower than 10 to the 2nd poise?

A Could I ask to have that repeated?

(Question read.)

A Yes, I have.

Q How do such higher temperatures affect the quality of the glass-bonded core produced?

A Anytime that you operate at high temperatures during glass-bonding operations you're getting into trouble areas. Often you get into gap deformation, irregularity of the gap, you get into chemical reactions, second stage reboil, coloration of the glass as a result of the reaction between the glass and the ferrite.

These are areas that one would like to avoid.

Q Let's take them one at a time.

With respect to irregularity of the gap, how does higher temperature produce that?

MR. CALIMAFDE: Your Honor, may I ask the relevancy of this question or this line of questioning?

THE COURT: I am having some problems with that. I would like to have the same response.

MR. RELSON: To make, in effect, an offer of proof, your Honor, what we are attempting to show by this testimony is that the very high temperatures, producing very low viscosities, very such deleterious effects as to inhibit their use, the use of such high temperatures, and it

* * *

Q In the Ferroxcube production of glass-bonded cores, does it use capillary action?

A Yes, it does.

Q In that context have you tried the varying temperatures which we have discussed?

A Yes, I have.

Q At the higher temperatures, did you obtain the type of results you were discussing a moment ago?

A Yes, that is correct.

MR. RELSON: I will go on to another subject, your Honor.

Q In your work with the customers of Ferroxcube, did the customers drawings and specifications come to your attention?

A Yes, they did.

Q What was your role with respect to that?

A I received the drawings from our marketing people. It was my function to review the drawings for correctness and interpretation of notes and numbers on the drawing. At that point I would either generate an AFX documentation for the use of our drafting department or I would refer it back to our marketing group with points for clarification.

MR. RELSON: I offer Plaintiff's 203-A.

* * *

there has been testimony concerning the shim heights used at Micronetics to satisfy the customers' requirements.

Would you state how at Ferroxcube the shim heights -- let me back up.

At Ferroxcube, does the Ferroxcube process use deposited shim for the purpose of separating ferrite bars in the manufacture of glass-bonded ferrite cores?

A Yes, it does.

Q Did you hear the testimony of Mr. Rivelli concerning the Micronetics process?

A Yes, I did.

Q Let me show you Exhibit 170 and ask you briefly to indicate any respects in which the Ferroxcube process differs from the Micronetics process as the Micronetics process is illustrated on that diagram.

A The term pressure transmitting wires has been crossed off here.

Q Start from the beginning and indicate which parts are the same and then indicate any differences as you go along.

A Basically we start with a ferrite brick as depicted here cut into slabs, form a C-Bar and I-Bar as shown, polish the two surfaces. We then clean the part, subject it to a deposition operation where the shims are

applied and in the area that would be indicated here by the dotted lines.

Q Are the shims applied on the I-Bar as in this diagram, in the case of Ferroxcube?

A Often it is done on the COBar although we do it on the I or C, whatever seems most appropriate. It doesn't make much difference.

Q Proceed.

A Going along to the assembly of the parts here, essentially it is the same with the exception that we use these pressure transmitting wires that have been apparently crossed off here. The glass rods are positioned in the same fashion, subjected to a bond cycle. The bar is machined and sliced and diced in the same way. Generally the core is lapped after the slicing operation and then the core moves to an inspection area.

Q Does Ferroxcube use a thermal etching step?

A Yes, it does.

Q At what stage in this process?

A We have a right -- we have actually two ways of thermally etching. The one as shown here where we assemble the parts and break them prior to bonding.

Another way we have when we are after quantity rather than quality, is to fire the parts prior

to assembling them.

Q By firing the parts, what do you mean?

A Before the parts are subjected to the deposition operation after lapping and cleaning, the parts are placed in a boat, put in an oven and fired at a temperature and time cycle both higher and longer respectivelythan the normal bond cycle.

Q Is that done in bulk?

A In the case where we are using the batc h kilns and the boats, it is done in bulk, yes.

Q What is the effect of that thermal etching?

A The effect that we have found is that it improves our yield. We have less chipping problems as a result apparently of the lack of bubbles being present. We have found it to be a better quality part.

THE COURT: Whab about these pressure transmitting wires, what do they really do?

THE WITNESS: We have found in order to have better control of the gap length, that the pressure is very important as to where it is applied. If you do not apply the pressure directly over the shims, we have found that you introduce bar bending, so you actually get a smaller gap than the shim you have deposited due tc apparently bar bending.

By the interjection of these transmitting wires, we could bring our gap lengths and shim heights to be very close.

Q In connection with bar bending, we are dealing here, are we not, with very small pieces.

What is the approximate width of the bar at Ferroxcube?

A Generally, we have two standard widths that we use. One would be .270 inches wide and the other would be .335 inches wide.

MR. RELSON: I will offer Exhibit 199-B.

(Plaintiff's Exhibit 199-B marked for identification)

THE COURT: Is there any objection?

MR. CALIMAFDE: No objection.

THE COURT: It is received.

(Plaintiff's Exhibit 199-B received in evidence)

Q Would you explain if you can what Exhibit 199-B shows, briefly.

A Yes. Basically there is a C-Bar and an I-Bar here that represent, I believe a machine condition and a lapped condition. There is also one bar showing the lapped C-Bar with the deposited shims. There is another bar

that shows the bar after being taken from the kiln after bonding.

The second bar underneath that shows the bar after being machined, after the bonding cycle and then there are two parts which represent cores which have been sliced and polished from that bar and there are two mating but the bars shown here as well which would be the part to complete the magnetic circuit of the core.

Q In the Ferroxcube process --

MR. CALIMAFDE: Excuse me, Mr. Relson.

Your Honor, it appears that this witness is giving considerable testimony about the procedures used in manufacturing at Ferroxcube and at his deposition on August 27, 1974 he indicated that he did not know the procedure at Ferroxcube and that he was not working in that area.

THE COURT: Don't you think that is excellent for you for cross examination?

MR. CALIMAFDE: I held back, your Honor, thinking that if it is two or three minutes I would forget it and take it up on cross. But if we are going to spend fifteen minutes or a half an hour discussing procedures at Ferroxcube, all of that to be weighted, because this man a few months ago said he had no knowledge about it, I wondered whether I should sit here and just wait the half hour before objecting.

THE COURT: Maybe he schooled himself inbetween August and today. That is another matter you can bring out in your cross examination. I am going to let Mr. Relson continue.

Q In the Ferroxcube process, what is the relationship between the shim height and the desired gap length range specified by customers?

A The relationship between the shim height and the

jhlt 2 Wank-direct

desired gap length essentially would be ideally equal. Essentially they are the same.

Q In practice, how close would they attain the idea?

A Well, may I use a specific example here?

Q Please do.

A For example, we manufacture one core where the gap length would be specified at 80 to 120 micro inches. The shim deposition that we are currently using to fabricate that part is 101 to 109.

Q In your work at Ferroxcube, have you made a determination as to whether during the bonding process, after the bars are assembled as shown in step E of the Exhibit 170 before you, whether the spacing between thebars change during subsequent processing through the steps of thermal etching and bonding of the glass?

A No, it does not change.

MR. CALIMAFDE: I object. There is no foundation for the question or the answer.

THE COURT: Sustained.

MR. RELSON: Would you read the question again, please?

(Question read.)

THE COURT: I will let him answer it.

Q First, answer whether you made such a determination.

A I have looked into this area and my findings are that they are not different.

Q That is, that the spacing between the ferrite bars does not change during the bonding step, is that correct?

A That's correct.

MR. RELSON: That's all, your Honor.

MR. JUDLOWE: Your Honor, if I may, as a preliminary matter, to shorten the cross examination, I would like to offer into evidence what has been marked for identification as Exhibit HH, which is a deposition of Vernon Morton, who was on the technical side from Ferroxcube, along with Exhibits HH-1 through 19, which were taken at the deposition of Mr. Morton, as well as the deposition of Mr. Wank, which has been marked for identification as Defendant's Exhibit II, together with Exhibits II-20 through 31, which were exhibits at the Wank deposition.

THE COURT: Any objection?

MR. RELSON: I would like a chance to look at the subsidiary exhibits. There is no objection to the depositions as such, but I believe that a number of these exhibits were not fully authenticated or are otherwise objectionable. May I

* * *

THE COURT: But you're not certain?

THE WITNESS: I am not certain.

THE COURT: Objection sustained.

(Defendant's Exhibit HH1-5, 7, 9, 10, 12-19, received in evidence.)

THE COURT: Does anyone have any other questions of this witness?

MR. JUDLOWE: Not the defendants, your Honor.

MR. RELSON: No, your Honor.

THE COURT: Mr. Wank, you are excused. Thank you very much.

(Witness excused.)

MR. RELSON: I call Mr. Oisher.

J A C K O H E R, called as a witness on behalf of the plaintiff, being first duly sworn, testified as follows:

DIRECT EXAMINATION

BY MR. RELSON:

Q What is your resident address, Mr. Oisher?

A 22 Kenneth Road, Hartsdale, New York.

Q By whom are you employed?

A The plaintiff in this case.

Q In what capacity?

A Patent attorney.

Q Have you been assisting trial counsel in this litigation?

A Yes.

THE COURT: Just so I can be sure, were all the Philips organizations, are you employed solely and exclusively by U.S. Philips Corporation, Mr. Oisher?

THE WITNESS: Yes, your Honor.

Q Is U.S. Philips Corporation wholly owned by the Hartford National Bank and Trust Company as trustee?

A Yes.

Q Is North American Philips Corporation approximately sixty percent owned by that bank as trustee?

AQ Yes.

Q Is Ferroxcube Corporation a wholly owned subsidiary of North American Philips Corporation?

A Yes.

Q Is there a corporate relationship between U.S. Philips Corporation and N.V. Philips?

A No.

Q Does U.S. Philips Corporation perform a function with respect to obtaining patents on inventions made by employees of N.V. Philips?

A Yes.

Q What function do you perform?

* * *

compilation of the U.S. patents held by U.S. Philips Corporation of which Mr. Simon Duinker, the inventor of the 318 patent here in suit, of which he was an inventor?

A Yes.

MR. RELSON: I offer Plaintiff's Exhibit 159, which contains a list and copy of each of such patents.

MR. CALIMAFDE: I can't imagine the relevancy of that, your Honor. I object to it.

THE COURT: Overruled. I would think the Court would be required to take judicial notice of this anyway, and though I have some difficulty in seeing relevance of other Duinker patents, I am going to take it.

MR. RELSON: If I may comment, your Honor, it reflects on the level of expertise of Mr. Duinker by showing his professional work, which in turn bears upon the question of whether something that he did not accomplish in a considerable number of years was or was not obvious.

THE COURT: I think an argument could be made. I don't find it very persuasive, but I have already told you I have ruled and I will admit the material.

MR. CALIMAFDE: Your Honor, to add the last chapter or the epilogue to that, the patent in suit, the Duinker patent, came I think a month after the GE article. He did not struggle many years looking for solutions to any

problem.

THE COURT: I think that is an unnecessary comment, counsel. You might save it for your closing or moving argument.

MR. CALIMAFDE: All right.

THE COURT: Both comments probably could better have been reserved.

MR. CALIMAFDE: That's right.

THE COURT: In any event, gentlemen, the objection which was lodged on grounds of relevance is overruled. I think that though it is a strained thought on the Court's part, there is an argument to be made to support the offer, and it may be made, because the offer has been accepted, the document is received.

(Plaintiff's Exhibit 159 received in evidence.)

THE COURT: Are these in the book?

MR. RELSON: No, your Honor. They were too bulky for the book. The list is, but not the patents.

THE COURT: I would note that Mr. Duinker applied for -- I won't try to count them, but you have about three pages of U.S. patents applied for by Mr. Duinker.

MR. RELSON: I may point out that the dates of those patents vary widely, so that some are after critical dates

* * *

on a running royalty basis. It would take IBM an enormous amount of money and time to keep a record of the actual use it makes of all of our patents. We have something like five to six thousand patents.

So, a lump sum arrangement is generally worked out based upon estimates by each side of the other's use and that generally is the arrangement.

Q Has U.S. Philips also licensed other companies under the Duinker and Peloschek patents?

A Yes, two others, a company called Arvin and a second called Afcoa. I think you have the agreements there.

Q Is it correct that the Arvin agreement is on the Duinker 318 patent only?

A Yes.

Q What patents does the Afcoa agreement cover?

A My recollection is the 318 patent is included and a second patent. The last three digits are 453, but I don't recall the preceding four digits.

THE COURT: Just to cover the thing thoroughly if I can, has U.S. Philips licensed the Peloschek patent aside from whatever license exists with IBM?

THE WITNESS: The only other one would be Ferroxcube and that agreement I think has been explained

to you.

THE COURT: Yes.

MR. RELSON: I offer in evidence Plaintiff's Exhibits 206 and 207 which are the agreements referred to by the witness, and may I suggest the witness might want to refresh his recollection on the Afcoa agreement from the agreement itself.

MR. CALIMAFDE: No objection.

THE COURT: They are both received. Let's receive them in first. As a matter of fact once they are in evidence, if you wish just to make a statement from the document, it's all right with the Court.

(Plaintiff's Exhibits 206 and 207 received in evidence)

MR. RELSON: Just briefly, your Honor, the Arvin agreement required a royalty payment of two and one-half percent of what were called licensed devices and licensed divices was defined to mean a magnetic sound recording head, and I emphasize head as opposed to core, embodying the invention of the Duinker patent.

Q Approximately how much royalty was paid under the Arvin agreements?

A I am sorry, I don't recall, but there should be an answer to one of the defendants interrogatories

which gave the number.

MR. JUDLOWE: Your Honor, if I can help out with what the witness said. We have the answer to Request No. 176 to admit and U.S. Philips has advised us pursuant to the Arvin license, it has received royalties on account of the licensed patents from the beginning of the license to date in the sum of $84.75, which roughly is payments in four quarters of $22.50; $20.50; $17.50; $24.25.

THE COURT: $84,75. During what period of time?

MR. JUDLOWE: All time, since the license has been in force.

THE COURT: I don't have the agreement in front of me so I don't know when that is.

MR. RELSON: The agreement was dated May 1, 1967 between a predecessor of U.S. Philips which is North American Philips Company Incorporated.

THE COURT: Shall I accept the figure that your adversary has stated?

MR. RELSON: I believe that to be accurate.

THE COURT: That is what has been received from Arvin.

Q The Afcoa agreement was a head -- a core agreement rather than a head agreement and it contained a long

list of patents, some three pages worth, including both the Duinker and Peloschek patents in suit and gave the licensee the option to select which of the group it desired with a progressive royalty rate of ten percent of the core selling price if a single patent listed in Group 1 of which Group 1 consists of the Duinker and Peloschek patents for a second patent five percent, for a total of fifteen percent under the first and second patents and by paying the fifteen percent, a blanket license could be obtained under all, that is, with a step up.

There was also some Group 2 patents at a lower rate which are not of concern.

Which patents were selected by Afcoa?

A It is my recollection they selected the 318 patent in suit and that second patent which I can only recall the last three digits 453.

THE COURT: In any event, they did not accept the Peloschek patent?

THE WITNESS: That is my recollection.

Q How much royalty was paid under this agreement?

A Perhaps Mr. Judlowe has the answer.

MR. JUDLOWE: Again I quote with some pleasure from plaintiff's response to request for admission

* * *

order of magnitude."

CROSS EXAMINATION

BY MR. JUDLOWE

Q Mr. Oisher, there has been some testimony about your unsuccessful attempts to license other people in the field.

MR. JUDLOWE: I would like to offer into evidence Exhibit NN.

MR. RELSON: No objection.

(Defendants' Exhibit NN received in evidence)

Q Mr. Oisher, I will briefly ask you to look at these documents. They are all subject to admissions and ask you whether or not each of them represents a communication with you and a potential licensee of the patents in suit and was not the license in each case not taken by the party to whom you communicated?

A The answer is yes.

MR. JUDLOWE: Your Honor, I don't want to belabor the record. Rather than reading the admissions, they are made by plaintiffs. They are admissions 59 to 85. The admissions come in what I will call cuplets. The first one is a request to verify the authenticity of one of those documents and the response and I will read one

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response -- I will read one cuplet so the Court is aware of what I am doing and I will name the other letter recipients.

Request No. 60, for example, the document marked by plaintiff with Bates Nos. 500002-6 is a true copy of a letter from Mr. Oisher to Burroughs Corporation dated June 26, 1970 admitted in the following admission, no license agreement covering any patent in suit is now enforced between plaintiff and Burroughs Corporation nor was there ever such an agreement, and there are admissions with respect to companies named Tranetics Inc. Those are admissions 62 and 63.

There are admissions with respect to magnetic parts. Those are admissions 66 and 67. There were admissions with respect to a company named Data Memory Inc. Those are admissions 68 and 69. There are admissions with respect to Century Data Systems Inc. Those are admissions 70 and 71. There are admissions with respect to a company Labtek Inc., admissions 72 and 73. There are admissions with respect to Bell & Howell. Those are admissions 74 and 75.

Admissions with respect to Ampex Corporation, admissions 76 and 77. Admissions with respect to Ferronicz Inc. Those are admissions 78 and 79. There are admissions

with respect to the Potter Instruments Company, admissions 80 and 71. There are admissions with respect to 3M Company admissions 82 and 83. Admissions with respect to Sperry-Univac, admissions 84 and 85. And there is also an admission with respect to Magnetic Head Corporation, that is admission No. 59.

I would also like to read into the record in conjunction with the IBM agreement admissions 176-F, the license agreement between IBM and the plaintiff which included the patents in suit. There is no allocation of royalties to any particular one or ones of the licensed patents or to any one or ones of the patents in suit, and I would also like to call the Court's attention in this regard to the stipulations which appear on the beginning of the pre-trial order which note explicitly that the dollar amount paid by IBM to U.S. Philips is matched exactly by the dollar amount paid to IBM by N.V. Philips and the Court will find this at Page 107 of the pre-trial order; Paragraph 6-D.

THE COURT: Which is what you call a wash.

MR. JUDLOWE: That is correct, your Honor.

Is that agreeable?

MR. RELSON: Yes.

MR. CALIMAFDE: Yes.

THE COURT: Needless to say, Mr. Calimafde has said it and the Court will say it a second time. We both accept this as an inadvertence. I am certain that Mr. Relson, who is well regarded by this Court as well as his adversary, was unaware of this and I appreciate, as I am sure Mr. Calimafde does also, his bringing it to the Court's attention at the first possible moment.

Is there anything else before we proceed with your recalled witness?

MR. RELSON: Mr. Kornei.

THE COURT: The plaintiff calls Otto Kornei. Since it has been some time since you have testified, Mr. Kornei, I will ask that the oath be administered a second time.

O T TO K O R N E I, recalled as a witness on behalf of the plaintiff, was resworn, and resumed the stand to testify as follows:

MR. RELSON: As a preliminary, I offer Plaintiff's Exhibit 178-1 through 4.

MR. CALIMAFDE: Your Honor, the chart has a claim but it also has statements in the righthand margin such

* * *

with respect to these Ferroxcube materials would be the same as the testimony you gave with respect to Micronetics material?

A It would be exactly the same.

Q Let's go to the Peloschek patents.

I don't believe you have testified regarding this patent earlier, is that correct?

A I have not.

THE COURT: But you were present throughout the testimony of Mr. Vrolijks?

THE WITNESS: Yes.

Q The trial brief for Micronetics stated that this patent is for "merely a method of filling a gap with glass."

Do you agree with that?

A No, I really don't. It is considerably more than that.

Q What are the important aspects in your judgment of the Peloschek patent process?

A The filling of the gap in the head is really only one aspect of the entire patent, a very important one to be sure, but it is only one aspect. What the real teaching of the Peloschek patent is, I believe, really represents a complete departure from previous technology

from previous approaches to the fabrication of magnetic heads. It is based briefly on the following:

The Peloschek patent teaches the preparation of the glass gap in a sintered ferrite head in the following way.

Q Just state this generally because I am sure the Court is already aware from prior testimony.

A To make it brief, we have two confronting ferrite faces in the head and we bring them by means of shims applied to one of the faces into an exactly predetermined fixed relationship. The relationship is such that the glass which enters this structure then forms the spacer and the filler in this structure and it does so by filling a predetermined gap which is in entire contrast to previous approaches where we had as your Honor will recall the so-called sandwich approach.

Either in the Duinker patent or in the entire history preceding this way back to the beginning of the invention of ring heads.

When a gap filler was always fastened between the two confronting faces, the two confronting faces were brought upon it. They were not in a fixed and predetermined relationship, which actually caused such heads always to be rather indefinite in regard to the ultimate result of

the gap length.

You really never knew exactly what the gap length was before you measured the gap in the finished head. This is totally different in the Peloschek patent where the gap length is completely and accurately predetermined.

Now, a very convenient and possibly the only practical way of filling this void in the Peloschek structure is by capillary force, by introducing the glass into the existing void by capillary force, but this does not mean that the patent describes capillary force only.

I sould like to add perhaps a few words on the significance of the Peloschek patent in the evolution of modern computers.

I believe it can be said without any exaggeration --

MR. CALIMAFDE: I object to this. I don't believe there is any foundation to this man's knowledge to give the testimony that he would like to give now.

MR. RELSON: This is an expert witness whose opinions can be given subject to whatever weight the Court desires to give him.

THE COURT: I am not quite sure I recall his expertise in what you might call computer technology.

Why don't you back up one question or advert to something in the record already that I did not recall just now.

Q Mr. Kornei, during your work at IBM, did you have knowledge of computer technology?

A I had knowledge of computer technology, although I was working primarily in research and development.

Q At IBM I believe you had the title of manager of storage technology.

A At one time it changed.

Q Was storage technology concerned with the computer art?

A IT is concerned with computer art, among other things.

MR. RELSON: I will resubmit the question.

THE COURT: I will take the answer. I am not sure of the weight I will give to it because of what has been said.

MR. RELSON: Could you read the question, please.

(Record read)

MR. CALIMAFDE: I will ask it be stricken because it goes beyond the question.

THE COURT: I will let it stand.

Q Would you continue your answer.

A (Continuing) It can be said without any exaggeration that without the Peloschek patent, the enormous numbers of magnetic recording heads required in modern computers could never be produced in an economical way and it was really the fact that heads were produced at a lower cost and lower price which contributed substantially to the development of the computers the way we know them today.

THE COURT: Yet what troubles the Court, gentlemen, is that except for IBM which pays $200,000 a year for 1,500 patents including Peloschek, no one, with the possible exception of Ferroxcube in a peculiar situation has seen fit to obtain a license for the Peloschek patent.

MR. RELSON: Your Honor remembers some of the figures. IBM had 60 or 70 percent of the whole market. Of the remainder there was a certain group which were in-house manufacturers and of those in the industry of making cores, the two companies who were mentioned in this case, Ferroxcube and Micronetics shared almost all of it; so we do have IBM plus these two covering a major portion of the entire production, leaving only those in-house manufacturers whose quantity has not been determined or is

not listed in this case.

So, it is not a question --

THE COURT: They seem to have gotten by even those though their quantities are modest.

MR. RELSON: This case has been pending a long time and the practicalities of listening are very difficult during pendency of an attack upon the patents, as I am sure you will realize. That has made some -- I wouldn't comment on the licensing aspects of U.S. Philips, but a lot will depend upon the outcome of this case.

THE COURT: I will listen further.

BY MR. RELSON:

Q You stated that the Peloschek patent represented a radical departure. What were the significant features that constituted this radical departure and just state them briefly?

A The significant teaching is the fact that the two faces of the head are brought together into an exactly predetermined and fixed position, determined by the insertion of shims and that this particular spacing between the faces is exactly the equal to the length of the gap in the finished head. Excuse me, I want to back off. I want to add:

The spacing of the two faces at the time when the liquid glass enters equals exactly the gap length

of the finished head.

Q Is this what leads to the ability to maintain close tolerances?

A This leads to the ability of very close tolerances in a very economical way.

Q Is there any pressure on the glass during the time it enters the gap?

A There is no pressure at the glass at all.

Q Is it correct or not that the glass does not affect the spacing of the ferrite pieces during the bonding process?

A Not in a normally practiced form. If the glass does not chemically interact with the ferrite, it will not modify the gap length.

Q Is there pressure applied at all?

A There is pressure applied to a small degree, merely in order to hold the two ferrite pieces in a mutually fixed and immovable relationship to each other.

Q With the shims in between?

A With the shims in betwee.

Q Would you compare that with the situation that has been testified to here sometimes called the sandwich technique in its various forms?

A In the sandwich technique we have an entirely different situation --

* * *

Q Referring to the clause A and its subdivision 1 of claim 10 of the patent, would you state whether or not that clause specifies a step which is followed in the Micro= netics process?

A It appears to be so because we must expect that the two ferrite faces which define the gap length are at the spacing determining the ultimate gap length at the moment when the glass enters.

We can, I believe, disregard any possible deformations which may have taken place in the preceding heating process, whether it does or does not include a so-called etching process. We must assume that at the moment the glass enters the gap and has the desired length.

THE COURT: You indicated by capillary action, the glass is not forced in, which would tend to force the gap length or the two faces apart, but in essence, it flows in under relatively little pressure, therefore permitting the gap length to remain essentially the same. Essentially the same or exactly the same?

THE WITNESS: I would say exactly the same.

Q Mr. Kornei, the Court mentioned flowing the glass in under slight pressure. Would you comment on the actual phenomenon by which the glass enters the gap in relation to whether there is any pressure or not on the glass itself?

A There is virtually no pressure at all. The glass is not really forced into it in the ordinary sense. It is sucked into the gap by capillary force and the force is exerted on the opening faces of the ferrite which are utterly negligible.

Q Would you refer to claim 1 in Exhibit 179A?

MR. RELSON: Mr. Calimafde, again, is it correct that the only issue here is as to clause A of the method and its subdivisions?

MR. CALIMAFDE: Yes.

MR. RELSON: I would merely like to ask whether there is an issue as to subdivision 2, clause 5.

MR. CALIMAFDE: There is an issue, but the case will not hang on it, I assure you.

MR. RELSON: I might refer the Court to the testimony of Mr. Rivelli that it made no difference whether the shims were at the precise ends of the bar or spaced slightly inward thereof.

THE COURT: I recall that. He said they spaced their shims in from the edge because of the masking material that was placed on the faces.

MR. RESLON: Yes.

Q Mr. Kornei, step A of claim 1 says "Placing spacing members having a thickness equal to the desired gap

* * *

Q Mr. Kornei, did you hear the evidence submitted by Mr. Wank concerning the process used at Ferroxcube?

A Yes, I did.

Q Would you state whether or not with respect to the patent claims of the Peloschek patent that Ferroxcube process differs in any material respect from the Micronetics process about which you have been testifying?

MR. CALIMAFDE: Your Honor, that is objectionable.

MR. RELSON: I am trying to make this simple.

MR. CALIMAFDE: We have Wank's testimony, not this man's interpretation of another man's testimony.

MR. RELSON: This man is being asked of the factual matters testified to by Mr. Wank.

THE COURT: Why don't you rephrase your question. Perhaps if you relate it to the patent, I will allow him to express an opinion. How much weight I am going to give to it, I am not sure, but I will at least permit the question to be posed in that form.

MR. RELSON: May I have the question read?

(Question read.)

MR. RELSON: I will rephrase that.

Q Will you state whether or not the Peloschek patent claims apply to the Ferroxcube process as testified to by Mr. Wank in the same way thatyou have applied these claims

to the Micronetics process?

A To the best of my recollection, the Ferroxcube process follows in accordance with Mr. Wank's statements, the Peloschek patent.

MR. RELSON: I offer in evidence Exhibit 179 which is the claims chart of the Peloschek patent.

THE COURT: I think here also we should deal with the reserved objection, if we can, to 178. The direct examination, I would assume is just about concluded, is that right?

MR. RELSON: Yes, sir. I believe 178 was admitted.

THE COURT: I thought Mr. Calimafde had reserved on it and I think it was admitted subject to a motion to strike at the end of the examination of the witness.

We will do the same thing with 179. 179 is admitted. You have reserved the right to strike it at the end of the examination of the witness.

(Plaintiff's Exhibit 179 received in evidence.)

xx

MR. RELSON: That concludes the direct examination.

THE COURT: Mr. Calimafde, you may inquire.

Off the record.

* * *

materials.

Q How about the non-magnetic materials that are used in conjunction with magnetic materials?

A Certain non-magnetic materials, of course, would be included.

Q Do you have knowledge of glass to metal bonding techniques?

A I personally?

Q Yes.

A Not very much.

Q When you say not very much, do you have --

A What you learn in the course of the years from occasionally reading a publication.

Q Are you familiar with glass to ceramic bonding techniques?

A Very little.

Q Ferrite is a ceramic, is it not?

A Right.

Q Do you have familiarity with glass to ceramic bonding techniques? My last question had to do with bonding materials. Now I am asking with regard to bonding techniques.

A I have not worked myself with this.

Q In your view is a skilled person in this field,

* * *

Take 6 p.m. rklt 1

THE COURT: Anything else, Mr. Relson?

MR. RELSON: Exhibit 137 was referred to during the course of the cross examination I believe of Mr. Rivelli when he explained what a disc file was. It was not offered previously, but as illustrative of his testimony, it might well be offered at this stage.

THE COURT: Is there any objection?

MR. JUDLOWE: No objection, your Honor.

(Plaintiff's Exhibit 137 received in evidence.)

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THE COURT: Is there anything else?

MR. RELSON: I think that is all and plaintiff rests.

THE COURT: Mr. Calimafde.

MR. CALIMAFDE: I call Mr. Gallup.

J O H N L. G A L L U P, called as a witness on behalf of the defendants, being first duly sworn, testified as follows:

MR. CALIMAFDE: Your Honor, I prepared qualifications of Mr. John Gallup in printed form to save the time of the Court. I thought perhaps I could offer that as Exhibit MMM.

THE COURT: Any objection?

MR. RELSON: We have just gotten this, your Honor.

rklt 2 Gallup

(Pause.)

MR. RELSON: I just notice that Mr. Gallup is said to have ten patents, but we have been given no information concerning any of them. As long as the reference remains this general, I would have no objection.

THE COURT: Very well. We will receive Defendant's MMM and the Court will consider the witness an expert sufficient so that his opinion may be elicited.

Needless to say the weight the Court gives will depend upon the use factors.

MR. RELSON: Your Honor, we would concede the qualifications in the field of glass to metal seals. However, it does not appear that Mr. Gallup is an expert in the field of magnetic recording heads or of magnetic recording devices.

THE COURT: Why don't we see what they elicit his opinion on. It may be it will be on the precise fields where he has this substantial expertise and they will by some other means present their proof in areas where you might feel his qualifications were less full or less complete.

MR. CALIMAFDE: Your Honor, I have for your convenience, Defendant's trial exhibit list. I will be referring to that now and then.

* * *

A Yes, sir. Then there is the Feinberg patent, number 3, 341,939.

Q That's Defendnat's Exhibit N. Briefly, tell us what that patent discloses.

A Well, this is again a method of bonding laminated electromagnetic cores.

Q By what process?

A By the flow under capillarity or by capillary flow in the bonding of electromagnetic cores.

Q Are there any other patents in this magnetic field which discloses the use --

A Well, there is a magnetic structure, patent number 2, 500,748.

THE COURT: That is Defendant's Exhibit G.

MR. CALIMAFDE: G, yes. Thank you.

A It is a method of a mortice and tenon arrangement and an alloy washer is caused to flow by capillarity between two components of the structure.

Q Is the mortice and tenon material a joint?

A Yes.

Q As disclosed in figures 2 and 3, are the two pieces joined but leaving a gap?

MR. RELSON: Objection as leading.

THE COURT: Yes.

A Yes. The picture --

THE COURT: The objection is sustained. Would you rephrase your question, please.

Q Would you describe the illustration in figures 2 and 3 with regard to the joint?

A Yes. I believe there are two magnetic components in a mortice and tenon arrangement and they desire to get non-magnetic material in a very small space to separate them, so they do it by putting a washer in there, melting it, and capillary flow causes the non-magnetic material of the washer to flow down between the two magnetic portions of the device.

THE COURT: Apparently he sought to use a material such as copper or a similar non-magnetic material, is that it?

THE WITNESS: That's correct, sir.

THE COURT: I see that. He calls this a brazing material.

THE WITNESS: Yes, sir. You can see that the space is very small between the two magnetic components, where the tenor protrudes into the mortice.

THE COURT: This so-called Grant patent was applied for in 1974, is that correct?

MR. CALIMAFDE: Yes, sir.

Q Mr. Gallup, are you familiar with any patent in

* * *

Q Mr. Gallup, you have that book of prior art, do you?

A Yes.

Q Will you turn to Exhibit P, which is a German patent, number 10546, and will you look at the English translation, please. Do you have it, sir?

A Yes, I have it.

Q It is entitled "Method of bonding laminated objects or objects composed of sheets and particularly magnetic heads."

A Yes.

Q Are we looking at the same patent?

A Yes.

Q Have you read that patent?

A Yes, I have.

Q Will you briefly tell us what that patent discloses?

A Well, this bonds magnetic heads by capillary attraction.

THE COURT: Action.

THE WITNESS: Capillary action.

Q Mr. Gallup --

A They dip -- again, they have piles or laminations of sheets which they dip into an adhesive and the adhesive flows into the gap between the laminations.

Q How does it flow between the laminations?

A By capillary attraction.

Q Can any material be made to flow by capillary action?

A Any liquid material can be made to flow by capillary attraction, providing that it wets the surfaces between which it is desired to flow them and -- this, of course, requires that the surfaces be clean and free from things which would prevent or inhibit the capillary flow.

Q Is there any limitation on the gap or the space with regard to whether a material will flow into it under capillary action?

A Well, of course, capillary action is merely a specific application, if you like, of surface tension forces. The surface tension forces always exist, but if it -- for instance, if you are thinking of a glass tube, if the diameter of the tube becomes too great then the surface tension forces are not sufficient to pull the liquid up into the tube beyond the meniscus at the edges. This meniscus is constant, doesn't depend on the diameter of the tube.

Now, whether this meniscus is enough to pull the liquid up into the tube or not depends on the diameter of the tube. The meniscus -- the surface tension is a constant for a given material. So you always will have to decide by

experiment whether the forces are sufficient with that particular liquid to pull it up into a tube of that particular diameter.

Q Your discussion sounds like a limitation on the upper limit of the space, how wide the space might be.

A It gets to a point where the surface tension is unable to pull the material into the gap.

Q Is there a limitation on the lower end of this range?

A There is really no practical limitation. It will flow into exceedingly minute spaces, even though you apply pressure on the device to force the materials together.

Capillary attraction -- providing the material wets the materials that you wish to have it flow between, it will still flow. You can't apply sufficient pressure to bring it close enough to prevent the flow. I haven't seen a case where you could prevent the flow by pressure.

Q You heard considerable testimony during this trial in regard to the smallness or the minuteness of this space.

A Yes.

Q The space in which the glass is flowed in the Peloschek patent.

A Yes.

Q From your experience and knowledge with regard to capillary, do you consider the space which has

been discussed in connection with Peloschek, a minute space for a capillary flow?

A Yes, that is a minute space in which capillary flow will certainly occur. The surface tension forces are enough for it to flow into that space.

THE COURT: Provided there is wetting.

THE WITNESS: Yes. If the surfaces were dirty, it might not flow with certain kinds of contaminants, greases and things like that, waxes, perhaps. They could inhibit or break up the capillary flow.

Q Is capillary flow limited to any particular external configuration in regard to the confined space, tubular or sandwich form?

A No, sir. It makes no difference as long as the materials are clean and the spacing is close, the surface tension forces are sufficient to pull the material in.

Actually, of course, it is atmospheric pressure that pushes it in.

Q Are contaminants capable of being removed from the surface of ferrites by a breaking process or heating process?

A Yes.

Q Have you read and do you understand the Pfost

* * *

size of the fillet you get would perhaps be controlled by the interaction of all three forces.

Q Assuming pressure is applied to the opening ferrite pieces tending to squeeze them together, what effect would that have on the capillary flow of the glass?

A That would have no affect, really, on the capillary -- it is an independent force, but the size of the fillet that you would produce might -- would be a function of how tight you squeezed it and how much glass you squeezed out from the capillary space and of course it depends on the diameter of the opening below the capillary space.

As you can see, the glass has flowed to form meniscus on the surface there. This is from the same surface tension force that causes the capillary flow. Capillary flow is due to surface tension, really.

Q Dr. Gallup, as a person skilled in the glass art, does the illustration of Figure 1 of Duinker indicate to you a process by which the glass fill the shaded area?

A Yes.

Q What is that process?

A Capillary flow, capillary attraction.

Q Are you aware of any statement in literature that would discourage consideration of the capillary

process in connection with the flowing of glass into a gap formed by ferrite pieces?

A No, sir, I am not.

THE COURT: Let me hear that question again.

(Record read)

Q In light of the prior art which you have discussed this morning, if someone prior to May 1962 asked you to consider different processes for filling a small gap with glass, would you have considered a capillary process?

A Yes, certainly, sir.

Q Would the results have been predictable?

A Of course you could try it but I would have expected that it would flow by capillary attraction. If you wanted to try any particular dimension, you would have to try it, I suppose, to see how far it would flow, but yes, certainly, capillary flow would occur.

MR. CALIMAFDE: No further questions.

MR. RELSON: May I have a couple of minutes.

THE COURT: We will take a five minutes recess.

(Recess)

THE COURT: You may proceed, Mr. Relson.

* * *

Q Isn't it correct that the Hill patent is directed towards attempts to improve the adherence between metal and glass?

A Yes, this is true, but as I said, this is what you are always trying to do.

Q Please answer the questions directly.

Isn't it true the Hill patent is directed towards the wetting power of a liquid to improve the adherence of metal to glass?

A Yes, that is true.

THE COURT: The liquid he is talking about here as I understand it is molten glass; is that correct?

THE WITNESS: Yes.

Q You read, or were directed to the paragraph beginning at Line 20 of Column 1 through Line 37. Do you see that paragraph?

A This is Column 1 Lines 29 through 37, yes, sir.

Q Isn't that a paragraph that could have been taken right out of a textbook just to discuss the principle of capillary action?

A Well, it is certainly explanatory of what capillary action is.

Q And it is not directed to any particular usage

of capillary action, is it?

A Well, not that particular paragraph.

Q So it is purely a discussion of principle, isn't that so?

A The principle of capillary action, yes.

Q With respect to the actual subject matter of the patent itself, is it not true that it is directed to a particular metal alloy which can be desirably bonded to glass?

A Yes, and the methods of improving the bonding.

Q With respect to the methods of bonding in this patent, isn't it correct that the only methods discussed are what are called the customary methods of bonding molten glass to the preformed metalic portions of the aforementioned alloys, inter-molecular attraction contributes greatly to the improvement of the obtained bond," and of course the customary methods employ capilarity as one of them.

Q And you are referring to the method you were concerned with at RCA, I take it.

A In that one case that you did not wish to hear.

Q With respect to this patent, and I refer you to Column 2 Line 2 starting with the word subsequently,

* * *

jhlt 1 Gallup-cross

Q In this Hill patent do you find any discussion whatever of introducing glass by capillary action between two spaced surfaces of ferrite?

A There are not specific practical directions for such, but may I point to line 47, in column 1. Should I read it or --

Q I think we can read that sentence.

A And if you consider surface tension a type of intermolecular attraction, which I believe it to be, and think that capillarity is due to surface tension, which the texts tell usit is, then you discover that he says that -- perhaps you consider it only by inference, but he certainly is saying it there, that intermolecular attraction, that is, surface tension, that is, capillarity, is one of the customary-- is a factor in customary methods of bonding molten glass.

Q Isn't it correct that the only material to be bonded to glass that is discussed in this patent is the alloy of platinum and silver which the patent describes?

A That is the only one -- well, may I look at the claims? Let's see.

MR. CALIMAFDE: I will be glad to stipulate.

THE COURT: Yes.

A It seems to say so, yes.

THE COURT: Platinum and silver.

* * *

But can you point out the line to me to read?

Q Line 6 of column 2.

A I expect this is actually mechanical pressure applied to the mold.

Q Yes. Would you now refer to the Grant patent, about which testified.

A Which exhibit was that?

Q Exhibit G. I refer you to the sentence beginning at line 4 of column 2. You see the reference there to a tight press fit?

A Yes, sir.

Q Doesn't that mean that when one part is inserted into the other it will not fit freely but must be pressed into place?

A Yes. The space between them is very, very small.

Q In fact a press fit is sometimes called an interference fit, is it not?

A I don't -- I am not familiar with that term.

Q In some cases a press fit is obtained by having an undersized hole into which the mating part is pressed, is it not?

A I am not familiar with that technique, but I can understand that it would work that way.

Q Isn't that what a press fit means?

A I guess that I am not familiar with that term.

Q You don't know?

A Tight press fit, to me it just meant that it fitted so tightly that it was difficult to get it in.

Now, you're saying that it means an undersized hole. I didn't know that.

Q If it is difficult to get in isn't it undersized in dimension?

A Not necessarily, because the materials, unless they were well polished, might be rough, and then it would be difficult to get in because of the roughness.

Q In the present case of the Grant patent, the melted copper flows into whatever intersticies remain between the two parts that were pressed together in a tight press fit, isn't that so?

A Yes. The capillarity forces it in or the capillarity forces bring it in, yes.

Q Then in Grant the two parts are not maintained separately or separated by a predesigned gap?

A Well, it is exceedingly small.

THE COURT: If you read the claims in Grant I am not so sure you're right. Claim 2.

MR. RELSON: Grant in claim 2 uses the term contiguous surfaces.

THE COURT: Read the end of it, sir, line 20.

MR. RELSON: Yes, your Honor, I will come to that.

Q But contiguous surfaces, isn't that correct, Mr. Gallup, that that means that the surfaces are touching?

A It means that they are in contact.

Q And if they are in contact they would not have a gap between them, isn't that right?

A No, that's not right at all.

THE COURT: That's not right at all. I agree with him.

Continue your answer -- I think you are working up the wrong tree here -- continue with your answer that that does not mean there is no gap between the surfaces which are "contiguous."

A It just means that they are very close together.

THE COURT: Very close, the gap is exceedingly small, is that right?

THE WITNESS: That's correct, your Honor.

Q So close that they are touching. The distance bewteen them is infinitesimal. But it is there.

If it were not so when you wanted to you could not pull them apart again. They would have fused, if you got them close enough, the molecules would have fused and you wouldn't be able to pull them apart again.

* * *

THE COURT: We had in addition to Hill, we had DeJean, Feinberg, Reichenbaum and that German patent by I think his name was Lietz.

They speak for themselves and I do not recall any reference to spacing members in any of the patents to which the Court has just referred.

Do you, sir?

THE WITNESS: I don't remember.

MR. CALIMAFDE: If you wish, I can direct your attention to patents which disclose spacing members.

THE COURT: I am talking about the ones discussed on direct examination.

MR. CALIMAFDE: That is right, sir.

THE COURT: That was my impression. I recognize there may be other patents which discuss spacing members, but the question, and my question too, was limited to those specific patents which you had referred to on direct. I coulan't recall anything. The witness couldn't recall anything and you have in essence verified our recollections.

Q Isn't it also correct that in each of these prior art references concerned with capillarity where two pieces were to be joined together with glass in between by capillary action, the two pieces were held as closely

together as they could be?

A I am trying to remember. There were the transformers.

To answer that, you would have to know the pressures applied. If they didn't apply considerable pressure, you wouldn't say they were held as closely together as they could be.

Q But they were held together with no intervening elements whatever, is that correct?

A Other than air.

Q There might be one minor exception which is the Reichenbaum patent. Initially before the capillary, in that patent which is Exhibit I, the two parts were held slightly apart, were they not, and I show you Exhibit --

A This is the heat zink device.

Q Yes. In this case, in Figure 2, the upper part 2, is held slightly above the lower part 1 at one corner of the material which, after heating flows into the gap?

A Yes. It seems to be tilted up.

Q And the upper part, 2, moves downward to as far down as gravity and the intervening material will allow it; isn't that right?

A Yes, sir.

Q Let me refer you to the German patent which is Exhibit P. That patent discloses a laminated core for a recording head, does it not?

A Yes.

Q It discloses that the laminations are held together by an adhesive; isn't that right?

A Yes, sir.

Q And the adhesive is introduced by dipping the clamped laminations into the adhesive; isn't that right?

A Yes. Should I look at the claims or at the description?

Q I was concerned with the description.

In this recording head, there is a gap, is there not, and I refer you to Figure 1 of the patent.

A That is in German and I don't read German.

Q ABB in German means Fig. and that would be Figure 1.

THE COURT: That would appear to be a small gap at the top of the ring.

Q Is the gap at the top of the ring indicated in any way in this patent as determined by capillary action?

A Can you rephrase that or refer me to a line?

Q Let me rephrase the question:

Is there any disclosure that you can find or know of in this patent to the effect that the two parts of the core on either side of the gap are joined together by material inserted by capillary action, and I believe the answer is no, so I cannot point out any passage to you.

THE COURT: Capillary action appears to be discussed at Page 2, about three-quarters of the way down the page after they describe dipping into adhesive and then these adhesive rises up in the capillary gaps between the laminations.

MR. RELSON: That is exactly the point I am making, your Honor. Adhesive is used here only for the laminatings and not for the gap with which this case has been concerned.

THE COURT: That would appear to be what the patent says. Let me turn to the claims. It would appear that the laminations are what are bonded together and the bonding is achieved by capillary action.

Q I want to refer you to a prior art reference cited by the defendant here, Exhibit R.

THE COURT: This wasn't gone into on direct examination, to my recollection, but I will not inhibit the cross for that reason.

* * *

only certain pages of this Zincke book. There came to my attention last night a copy of the book and another page in the book which is pertinent here. I have had no chance to do more than get a translation by Mr. Kornei of two paragraphs of that book from Page 142. I have not been able to show it to Mr. Calimafde.

MR. CALIMAFDE: I haven't seen it and I will object to it on the same basis that you objected to my book. I don't know what it is referring to. I have not read any other page but just on general principles, I will object to it.

THE COURT: I will overrule the objection and give you an opportunity to look at it. Basically a book is a complete document and if you choose to refer to certain pages of it, it does seem to me that you open the door to your adversary responding relative to other pages.

Since he is only talking about one page, I will give you the opportunity to look at it.

MR. CALIMAFDE: This page is not in close proximity to the four pages we identified. It is a statement out of context. I cannot accept the translation even as a translation offered to me and I would submit if this were to go in -- well, it seems silly to offer the entire book then we have a big job of translation.

THE COURT: I will do like I do with the depositions. He will put this in, youcan offer the book, you can translate it between the end of the trial and the presentation of the findings and conclusions. If you find something which knocks this page out because it is out of context, it seems to me you could say so and that would erase any advantage that appears to be given at this time.

It seems since the book is known to you and the fact you chose to select certain pages should not preclude. One page does not seem onerous. I will permit the book to go in if you wish. You may proceed, counselor.

MR. RELSON: Your Honor, if Mr. Calimafde insists, we will have the translation authenticated by Mr. Kornei who is highly qualified in this area when he is called on rebuttal.

THE COURT: Let's get on with the examination, counsel, because your rebuttal will be taking place tonight if you don't move things along.

Q Mr. Gallup, I read to you one paragraph from the Zincke book and ask you to listen to it. I can show it to you as I read it.

"However, one must consider a certain behavior of the solder during the operation if one wants to avoid mistakes. In contrast to metallic solder, glass solder remains practically at the spot where it is applied. It cannot enter narrow gaps, at least not at normal working temperatures. Therefore, it must be applied at the spot at which it is supposed to remain after the operation. For reasons of stability of the resulting fusion bond it is not advisable to make too big the space between the two parts which are to be joined by solder."

Does that express upper and lower limits of the gap useable for introduction of glass by capillary action?

A Not really, no.

May I make an observation? I do not agree with that. I have invented solder glasses myself and they are -- if you get up in the softening range they become fluid very, very suddenly, and they will run all over the bench. They are sometimes much more fluid than the ordinary zinc tin metallic solder or lead tin solders sometimes. It depends on the composition.

Q You said a moment ago that the viscosity of

water was 100 poises, is that correct?

A Yes, a centipoise.

Q Do you recognize the Handbook of Chemistry and Physics as an authoritative standard work?

A I have one at home, yes.

Q I refer you to page F34 -- by the way, this is the 53rd edition -- which defines centipoise as 1/100 of a poise.

A I think that is a mistake.

Q It defines centistoke as 1/100 of a stoke, does it not?

A Yes, it does.

Q A centimeter is 1/100 of a meter, is it not?

A A centimer is -- yes.

Q Don't you know that from your own knowledge?

A Yes, I know that one centimeter is 1/100 of a meter, yes, sir.

Q You still insist that centipoise is 100 poises rather than 1/100 of a poise?

A I learned that it was -- one of your witnesses I remember also said that, that the viscosity of water -- I am not sure which one of your witnesses said that -- was a centipoise, if I remember rightly.

Q I also show you a line on the same page which says

"The value found for the viscosity of water at 20 degrees c was .010091," etc., "poise."

A Then this must be correct. Your witness and I have -- were wrong.

Q The statement you ascribe to my witness was merely that viscosity of water was one centipoise, which was correct, was it not?

A Yes, that's correct.

Q And is it not correct that at the melting point as defined by Espe glass has a viscosity of 10,000 times the viscosity of water.

A I haven't written this down.

Q You have the exhibit before you.

A It seems reasonable, that is to say, glass -- at what temperature did you say glass -- the viscosity of glass varies -- what temperature did you say the glass was that you wanted me to compare?

Q Glass at the melting point as defined by Espe.

A I still say that there is no such thing as a melting point for -- there is a softening range and a melting range, but on a liquid how -- something that is liquid all the time, how can you speak of a melting point? Crystalline substances have melting points, but I think that something like glass is liquid all the time. That's my feeling. I

THE COURT: Mr. Kornei, we will have the oath administered to you one more time since it is a while you have been on the witness stand.

O T T O K O R N E I , having been called as a witness on rebuttal, was resworn and testified further as follows:

DIRECT EXAMINATION

BY MR. RELSON:

Q Mr. Kornei, do you have the prior art exhibits submitted by defendant in this case?

A This is Exhibit 151?

Q No, defendants prior art, Exhibits A through R.

A Yes.

Q I refer you to Defendants' Exhibits A, B and C, namely the Berger patent, the Hull patent and the Kingston patent.

These have been referred to as relating to glass to metal seals.

Would you state whether or not in your opinion a person in the magnetic head recording art would refer to patents on glass to metal seals in connection with the problem of avoiding chipping of ferrite edges in glass-

* * *

jhlt 2 Kornei-direct

A I believe that people active in the magnetic recording field are unlikely to look into these type of sources.

Q I refer you to the Grant patent, which is Exhibit G of defendant. To what type of structure is the Grant patent directed?

A This describes the structure of an electromagnetic relay.

Q What if anything does this patent teach with respect to the problem of being able to produce glass-bonded ferrite cores having gap lengths reproduceable within pre-defined tolerances?

A I don't believe it bears any relationship to this problem.

Q Would you explain your answer?

A The structure depicted here in figures 1 and then 2 and 3 represents an electromagnetic relay with a closed magnetic circuit. This circuit for certain reasons is interrupted or is to be interrupted by a non-magnetic gap in which in accordance with this invention is presumably generated by this mortise and tenon structure shown in figures 2 and 3.

The main idea expressed is the following:

The tight fit between mortise and tenon shown in

figure 2 is, so the patent says, partially filled with a brazing material denoted as 13, shown as a washer 13 in figure 3 -- in figure 2. The solder or the brazing material is presumably flowing into the interface between mortise and tenon, as shown in figure 3.

I must make a personal comment here. Figure 2 shows no gap whatever between mortise and tenon and figure 3 after the solder has entered this joint, suddenly does show a gap, which is hard to explain.

At any rate, in the tension of the patent it is explained that there is a press fit between mortise and tenon which if anything at all, will leave only very small and partial intersticies between which can be filled with the brazing material.

The actual magnitude of this gap, of this non-magnetic gap which is created then by the brazing material, is of really no consequence in this structure, so long as there is a break there.

THE COURT: Just stop right there for a moment, Mr. Kornei.

THE WITNESS: Yes.

THE COURT: Why use a non-magnetic gap filler if it doesn't matter that some of the magnetizable members come together? Won't the joinder of those magnetizable members

destroy the effect you wish to create in this device? Don't you require a separation by a non-magnetized gap?

THE WITNESS: Yes, you do, your Honor, but this non-magnetic separation is there at any time, if there is one in the press fit.

The purpose of the brazing material, the way I can understand it, is merely to make the structure rigid, but it does not change the nature of the gap.

THE COURT: But there is a gap, not a partial gap, is that correct? In other words, there is no point in the gap where the magnetized or magnetizable material on each side of the gap comes together, is there? Wouldn't that destroy the effect of the device?

THE WITNESS: Well, in a circuit of this kind we talk of the reluctance, it is called, or really it is, in simple words, the resistance which the joint offers to the magnetic flux, and this resistance he does not talk in the patent about it, but it is obvious what the aim is -- and this resistance is really independent of the fact whether there is air inbetween or a non-magnetic material. The only purpose of the non-magnetic material is to relate the mortise and the tenon into an immovable or, as he points it out, fixed relationship.

Your Honor yourself mentioned this. In the claim

number 2 at the end he says to form there between a permanent non-magnetic gap of fixed dimensions.

Now, these dimensions are there anyway. The purpose of the brazing material is merely to keep these parts from twisting with respect to each other.

The gap, however, is in no way predetermined. The way I understand fixed dimensions, they are dimensions -- I wouldn't know how to determine these dimensions. They are fixed merely because once the brazing material is in place they cannot change anymore and they do not twist with respect to each other, the two parts.

THE COURT: I recognize there are no gap spaces or shims. I see that. But it does seem to me that this gap filler runs the entire length of the gap, it is not interrupted. Am I correct or am I wrong?

THE WITNESS: Well, this depends on the nature of this very tight joint.

In my understanding, this joint between the tenon and the mortise would be -- since the two parts probably did not have perfectly smooth surfaces, they would have ridges and cavities, and in some cases you have metal to metal contact, in other cases you do not. It is a highly irregular interface.

THE COURT: Where does it say in words or by

inference that you have metal to metal contact?

THE WITNESS: Well, I would infer this from the statement that it is a press fit. The very nature of a press fit indicates that you have metal to metal contact. Otherwise, it just couldn't exist.

MR. JUDLOWE: Your Honor, if I may be helpful on the point, in column 2, beginning with line 26, there is a definitive statement on the point.

"This film 12 of brazing material wets the surfaces of the tenon and the mortised member and flows between these surfaces so that there is no iron to iron contact upon completion of the brazing operation. The thin film and sleeve of non-magnetizable material provides a permanent non-magnetic gap of fixed dimension."

THE WITNESS: I may have overlooked this, but this seems to my mind, to my interpretation, seems to be in contrast with the statement that the two parts are brought together in a press fit.

THE COURT: Your inference, I must say, seems to be contradicted by the plain words which have just been read to the Court, sir. I overlooked those words also. But it says no iron to iron contact. That is to me quite clear.

All right, let's go on.

BY MR. RELSON:

Q Had you completed your statement?

A Yes, I did.

Q Considering that this patent is directed to a magnetic structure for relays, as I believe you stated, in your opinion, would or would not a man of ordinary skill in the art of magnetic recording heads apply to art concerned with such a structure we faced with the problem of producing glass-bonded ferrite cores of gap lengths within predefined close tolerances.

A I would say definitely not.

Q Exhibit H is the Duinker patent in suit. Would you state whether or not the Duinker patent relies upon the use of capillary action for inserting the glass in the gap of the head shown.

A Not for the insertion of glass into the gap. The glass is inserted by mechanical means, simply placed there.

THE COURT: What about for the addition of the fillet? Is capillary action utilized there to make up the fillet?

THE WITNESS: The generation of the fillet is certainly based on the existence of wetting between glass and the surface, but the fact that a liquid wets another surface does not imply capillary action alone.

THE COURT: In other words, you can have wetting without capillary action but you cannot have capillary action without wetting?

THE WITNESS: Absolutely right.

Q Does capillary action contribute in the Duinker patent to the formation of the gap to any significant extent?

A I don't believe so.

Q Would you turn to the Reichenbaum patent, which is Exhibit I. Do you have it?

A Yes, I have it.

Q What is the general subject matter of the Reichenbaum patent?

A The subject matter is to join metallically a semi-conductor to a heat sink, which is simply a big pieces of metal.

Q Is this essentially a metal soldering problem?

A It is a metal soldering problem.

Q What does Reichenbaum teach if anything as to the problem of producing gaps in glass-bonded ferrite cores with gap lengths reproduceable within predefined close tolerances?

A There is no mention made of glass-filled gaps in this patent.

Q Would a person of ordinary skill in the magnetic recording head art have reference to this patent if faced with

the problem of producing gaps in glass-bonded ferrite cores having lengths reproduceable within predefined close tolerances?

A Definitely not.

MR. RELSON: Your Honor, Defendant's Exhibit J is a different Duinker patent from the one in suit, and I don't believe was referred to by Mr. Gallup. I will only comment that it was one of the prior art patents referred to by the patent examiner during the prosecution of the Peloschek patent.

The same statement applies to Defendant's Exhibit K, which is still another Duinker patent.

However, if I may, I will ask the witness a general question or two concerning these.

THE WITNESS: I must find the references again. I am terribly sorry. This is a completely different arrangement.

THE COURT: I note something in K. Duinker still seems to be talking about glass foil.

MR. RELSON: Yes, sir, and that was the general type question I was going to bring out.

MR. JUDLOWE: On that Exhibit K, your Honor, if I may interject while the witness is looking for his art, this is a prior art instance of the use of shims before the

Peloschek work.

THE COURT: Yes, I see he talks about the spacers there. They appear here.

I think in relation to Peloschek, which we are going to be getting to and dealing with, there doesn't seem to be any question that the different components which aggregate the method were known to people of what I would call ordinary engineering skill. The big question is whether the grouping of the components in the way they were grouped in Peloschek falls within that same definition.

MR. RELSON: There is one additional point, if I might mention it, your Honor.

THE COURT: I would like to hear you.

MR. RELSON: The term shim is used in this Duinker patent and the term shim is used in the Peloschek patent. The piece is called a shim, but the function which the piece performs in the process of the respsective patents I submit is different, and I can bring this out.

THE COURT: Oh, yes, I would agree. I would think, that the shim in the Duinker patent is what would be called a moveable shim, among other things, where the shim in Peloschek is, as I understand it, ultimately placed in one position in a secured way.

MR. RELSON: In the first case it is inadvertently

moveable, your Honor. It is not intended to be moveable, but it does, which is one of the problems that had to be overcome.

I will ask the witness a question on this which might clarify it for you.

Q Do you have the Duinker 367 patent before you?

THE COURT: Or Exhibit K if you have the book.

A I have it.

Q Mr. Kornei, would you explain the function and purpose of the shims in this Duinker patent 367?

A The purpose of shim acts as a stop. In the original Duinker patent in suit, the glass was squeezed until it had obtained the desired thickness which had to be found by cut and tried or by imperical means, the condition.

In this particular case, we are again dealing with squeezing of a softened foil of glass which the squeezing operation comes to an end when the two ferrite pieces hit upon the shim which acts as a stop for the squeezing operation, thereby defining the final thickness of the glass foil.

Q In this patent, does the upper ferrite piece move during the course of the bonding operation?

A Yes, it does.

Q In the Peloschek patent, does it?

A It does not.

Q Also with respect to the preceding Duinker patent, which is Defendants' Exhibit J, which is Patent No. 3,094,772, would you state whether or not that is of

the sandwich type in which the pressure squeezes the glass out?

A This is also of the sandwich type and if I may add to this, all known magnetic heads prior to Peloschek were of the sandwich type.

Q Does this patent, Exhibit J. teach a solution to the problem of avoiding the presence of bubbles in the glass in the gap?

A No.

Q Similarly, does the second Duinker patent which is Exhibit K, teach a solution to that same problem?

A No, it does not, either.

Q Referring to Exhibit M, which is the DeJean patent, that is entitled "Method of Assembling and Bonding Together Laminations to Form Laminated Cores of Electrical Inductive Devices."

What is the relationship if any between the cores indicated here and the cores that we have discussed in connection with the glass-bonded ferrite cores?

A Well, a core in a glass-bonded ferrite head consists of a solid piece of ferrite. This magnetic core here is made up of a stack of individual magnetic laminations which are bonded together by cement.

Q Where are the lamination stacks used in

connection with the DeJean patent?

A They are used -- generally speaking, equipment used in power engineering, motors, generators, transformers.

Q What if anything does the DeJean patent teach with respect to the problem of producing cores for recording heads having gap lengths reproducable within predefined close tolerances?

A In this respect, it teaches nothing.

Q Would you state whether or not a person of ordinary skill in the magnetic recording head art would apply to a patent in the art of laminated cores of electric inductive devices such as Dynamo Electric Machines for assistance in solving problems in obtaining glass-bonded ferrite cores with gap lengths reproducable within predefined close tolerances?

A I don't believe he ever would consult these sources.

Q Refer to Exhibit N, which is the Feinberg patent, what type of structure is there disclosed?

A This patent really somewhat is related to the DeJean patent. It also described the bonding of a laminated magnetic core for a transformer or similar device.

Q Does your testimony with respect to DeJean, which you just gave, apply equally to the Feinberg patent

or not?

A It would.

Q Would you refer to Exhibit O, which is the Hill patent.

Would you describe briefly the teaching of that patent.

A This patent describes a special alloy, specifically a high platinum percentage alloy which is regularly wetted by glass and can be used for air-tight bonds between metal and glass, especially through, as it says here, electrical lead in conductors into glass containers.

Q Does this disclose one type of metal to glass seal of the general character of the earlier Exhibits A, B and C, namely the Berger, Hill and Kingston patents?

A Yes.

Q This patent has a paragraph that is referred to during the testimony earlier which describes the phonemenon called capillarity beginning at Column 1, Line 29.

A Yes.

Q What is the significance of that paragraph with respect to the type of structure described by Hill?

A I would look at this as some sort of tutorial

paragraph to explain the general phenomenon of capillarity.

Q Does this patent describe a use for capillarity?

A It explains the phenomenon in general.

THE COURT: Is that explained at Line 47 where it says, "By applying the customary methods of bonding molten glass..."?

In other words, is this material which is mentioned in the prior paragraph one of the "customary methods of bonding molten glass"?

That appears to be the context of what he is saying.

THE WITNESS: The so-called customary methods are based on the wetting ability of glass to metal and in turn, capillarity is based in part on the wetting ability, but in order to obtain or to generate an air-tight glass to metal seal, the phenomenon of capillarity in my opinion directly is not used.

THE COURT: What does he mean then when he says customary methods of bonding molten glass there at the line that I just mentioned and also he goes on in Column 2, Line 2, "Subsequently the bonding of the metalic portion to the glass portion is performed according to any of the known methods."

What is he talking about? Are they so well

known he doesn't have to describe them?

THE WITNESS: They are quite well-known. They have been practiced for many, many years prior to it and the way I can see it, the primary purpose or the only purpose of this patent is to describe a particular alloy which can be readily wetted. He has no reference whatsoever, especially not in the claims, to a specific product, to a specific product.

THE COURT: You say when he says any of the known methods, you say he is or he is not including the so-called phenomenon called capillarity?

THE WITNESS: In the strict sense of the word, he is not.

THE COURT: In other words, it is your statement that the paragraph which begins at Column 1 Line 28, "The free surfaces of liquids show the phenomenon called capillarity," then goes on. That paragraph is completely unnecessary, completely irrelevant, has no connection whatsoever with his patent; is that basically what you are saying?

THE WITNESS: One cannot say it has no connection. It has connection insofar as capillarity is based on the wetting ability of a liquid to a solid surface.

Capillarity is closely related to it, but your Honor, if you really ask me whether this paragraph is necessary, I would have to say no, I don't think so. It does not really contribute anything to the teaching of the patent.

THE COURT: Doesn't it give an example of one of the customary methods, he uses that word at one point in Column 1 as I recall, and known methods which he uses in Column 2 line 4, for bonding metal to glass.

Isn't this one of the methods, customary or known methods for doing this?

THE WITNESS: The method has been known. The only teaching of this patent is the particular alloy he proposes.

THE COURT: Thank you.

Q Mr. Kornei, would you state whether or not the subject matter of this patent would be included in the subject matter consulted by a person of ordinary skill in the art of magnetic recording when faced with the problem of producing recording heads having gaps with gap lengths reproducable within predetermined close tolerances?

A I don't believe it is at all relevant in regard to the art of magnetic recording.

Q Would you turn to Exhibit P, the German patent.

This patent is entitled method of bonding laminated objected composed of sheets and particularly magnetic heads.

Are such heads among the laminated heads which you testified to in the early stage of this trial?

A Yes, they were the usual heads.

Q Was this patent directed to the method of laminating such sheets for use in magnetic recording heads?

A It is directed toward cementing the individual laminations together into a solid stack.

Q To what extent if any is the method of this patent indicated as used in the formation or bonding of the pole pieces? I should say formation of the gap or bonding of the pole pieces.

A The patent makes no particular reference to the formation of the gap. It merely discusses the bonding of the individual laminations and despite the fact that the laminations are bonded by using capillary forces, it evidently didn't occur to the inventor that capillary forces could be used in the gap fillers.

Q Is there or is there not a teaching in this patent how to produce cores with gap lengths reproducable

within predefined close tolerances?

A No, not at all.

Q I refer you to Exhibit Q, which is the Espe article. Is this article directed to glass to metal seals?

A Yes, it is.

Q Would you state whether or not your earlier testimony today concerning the Burger patents and the others of similar type would apply equally here?

A It is of the same general classification as the Burger and the other patents dealing with glass to metal seals.

Q Would you refer to Exhibit R, which is the Zinkce publication. In general, what does that publication refer to?

A It concerns -- I have a very incomplete translation here, only the first part. To which particular page would you like to refer?

Q We have been referred to certain isolated pages, namely, page 169 alone and pages 176 and 177. So first refer to page 169.

A This is said to be a ceramic to metal -- pardon me -- is said to describe a ceramic to metal joint.

Q What relationship if any does this subject matter have to the subject matter of the present litigation?

A No direct relationship.

Q I refer you to pages 176-177. Does this refer to production of ceramic to metal seals?

A Yes.

Q Wuld you state whether or not ceramic to metal seals are of the same general category as glass to metal seals?

A May I make a special comment to it? It appears to me, at least it was apparent at one time to me, that this ceramic to metal seal in this particular case, the way it is described really describes a metal to metal seal, since the ceramic was previously metallized in different ways.

Q What do you mean by metallized?

A I don't know how it was metallized. Possibly by vacuum deposition or by chemical means or in some other wyas. But the joint, the metal which is joined to the ceramic, is joined to a metallized surface part of the ceramic.

Q Then the soldering is between that metal surface and a metal part?

A Yes.

Q Would that be a type of metal soldering rather than ceramic to metal soldering?

A It seems so.

Q Would a person of ordinary skill in the magnetic recording art have reference to publications on the subject matter of the Zinkce publication we faced with the problem of how to produce glass-bonded ferrite cores having reproduceable gap lengths within predefined close tolerances?

A I do not believe so.

Q Considering generally the prior art which you have referred to in your testimony this afternoon, would you state whether or not the prior art teaches that capillary action should be used for the purpose of reducing bubbles in the gap of a glass-bonded ferrite core?

A This particular aspect has not been described in any of the publications or patent.

Q Would you generally characterize the Peloschek patent in suit and what you understand its contributions to the art to be?

A I think it can be said that the Peloschek patent was a real milestone in the development of magnetic heads, especially when one considers the economic aspects. Good heads have been produced -- good ferrite glass-bonded heads have been produced in accordance with the Duinker teachings also, but it was a cumbersome, expensive and not very reliable method. The yield of this method was low because the prediction of the exact gap length was very difficult indeed. It did not lend itself at all to mass fabrication.

In contrast to this the Peloschek patent for the first time has made it possible to obtain close tolerance and inexpensive mass fabrication of glass gapped ferrite heads.

* * *

action plus shims equals Peloschek. Do you say that?

THE WITNESS: An added qualification would have to be made in regard to the shims. In other words they are placed, to begin with, and the two pole faces are clamped onto these shims, which is not the case in Duinker.

Q So that I understand all the conditions which in your view distinguish one from the other, they are the use of shims, capillary action and the clamping of the ferrite pieces against the shims?

A And a final distinction:

The glass is sucked in purely by capillary force from the outside, which is not the case in Duinker. I do remember somebody said there was capillary action involved in the bonding of the glass sliver to the face also, which in my opinion is debateable.

Q I don't want to get involved --

THE COURT: I would like to hear the end of the answer.

THE WITNESS: Which in my opinion was debateable.

THE COURT: Was debateable?

THE WITNESS: Yes.

THE COURT: Thank you.

Q Mr. Kornei, I don't want to get involved in what other people said. I only am interested in your testimony.

* * *

you continue down to line, about 48, where fixation of the two halves must be effected at temperatures between 500 degrees c, a molten glass layer being interposed between them.

Here he is referring to the same process, but he uses the word "softening" in one case and uses the word "molten glass" in the other case.

Isn't it true, Mr. Kornei, that in order to obtain the meniscus as shown in Exhibit 3 for the fillet, the glass must have been made molten?

A Here again, I must say I am no glass specialist. I can only express an opinion that the meniscus of this type could form even in a merely softened glass if you give it enough time.

Q Assuming that this is a manufacturing process where you cannot give it days or weeks, but you are manufacturing it and hopefully at some profit.

A If you want to do it fast and soften it only, it wouldn't enter the gap.

Q I said in order to obtain the meniscus and the layer of glass as shown in figure 3, isn't it necessary to melt the glass so it flows and spreads as indicated in figure 3?

A Ordinarily, I would say yes. At the same time,

please let me add this:

The Duinker process is definitely based on softening only. The whole Duinker process wouldn't work with molten glass.

Q You are saying that, Mr. Kornei, but all I can do is read these various Duinker patents and try to understand his drawings and we try to understand his language and he seems to use words like "molten" and "softening" to describe a condition which is illustrated, for example, in figure 3.

A Yet.

Q Yet, you would agree to achieve the configuration of the glass as shown in figure 3, that would require a melted or molten glass.

Let's assume that it does, sir, let me take it from there. Let's assume that in the Duinker patent the glass is made or heated to the molten temperature and continue with my hypothetical question with spacers and the absence of the glass foil.

Isn't it a fact the glass would then flow by capillary into that gap?

A If the glass were a liquid, actually molten, low viscosity, then it might do it.

Q If it does, then you have Peloschek?

A Pardon me?

* * *

THE COURT: And that would block the capillary action that would take place if the glass foil were not there and the gap were free?

THE WITNESS: Right.

MR. CALIMAFDE: No further questions.

REDIRECT EXAMINATION

BY MR. RELSON:

Q I am frankly unclear about this somewhat hypothetical question which had gone through several metamorpheses.

In the hypothetical question that was asked, I think it was asked in the sense that the shim was inserted and it was not made clear whether the shim was in contact with both of the ferrite faces or was in contact only with one.

Can you tell us, in respect of the ultimate question of whether or not the Peloschek process would be obtained through the accumulation of hypothetical points, would you tell us what would be requred of the shim in order that the hypothetical process be the Pelcschek process?

A Well, the answer to this is very closely related to the last answer which I gave. The shim in the Peloschek patent is in hard and solid contact with both confronting faces from the beginning of the process on. In the Duinker

process, no matter which patent it is, the shim is attached or lies on one side only.

The second confronting ferrite face moves slowly through the soft glass layer until it hits the shim as a stop, so this is a fundamental difference.

Q So that in order to build up a hypotnetical compilation of features which would add up to the Peloschek process, is it or is it not necessary that the shim be specified as in contact with both of the ferrite faces?

A Yes, it would have to be specified.

MR.RELSON: I have no further questions.

I have a little housekeeping.

THE COURT: We will take care of that in a moment.

Any other cross?

MR. CALIMAFDE: No.

THE COURT: I would like to be enlightened on one thing. I am not sure if the witness can do it or if counsel can do it, but during the course of your examination, Mr. Kornei, you said essentially that it would not be expected that a person doing research would look at one or another, actually all of the patents or find all of the patents which, or any of the patents which are listed by the defendant as prior art. I am not a patent specialist and I am trying to ascertain why that would not be the case in a big

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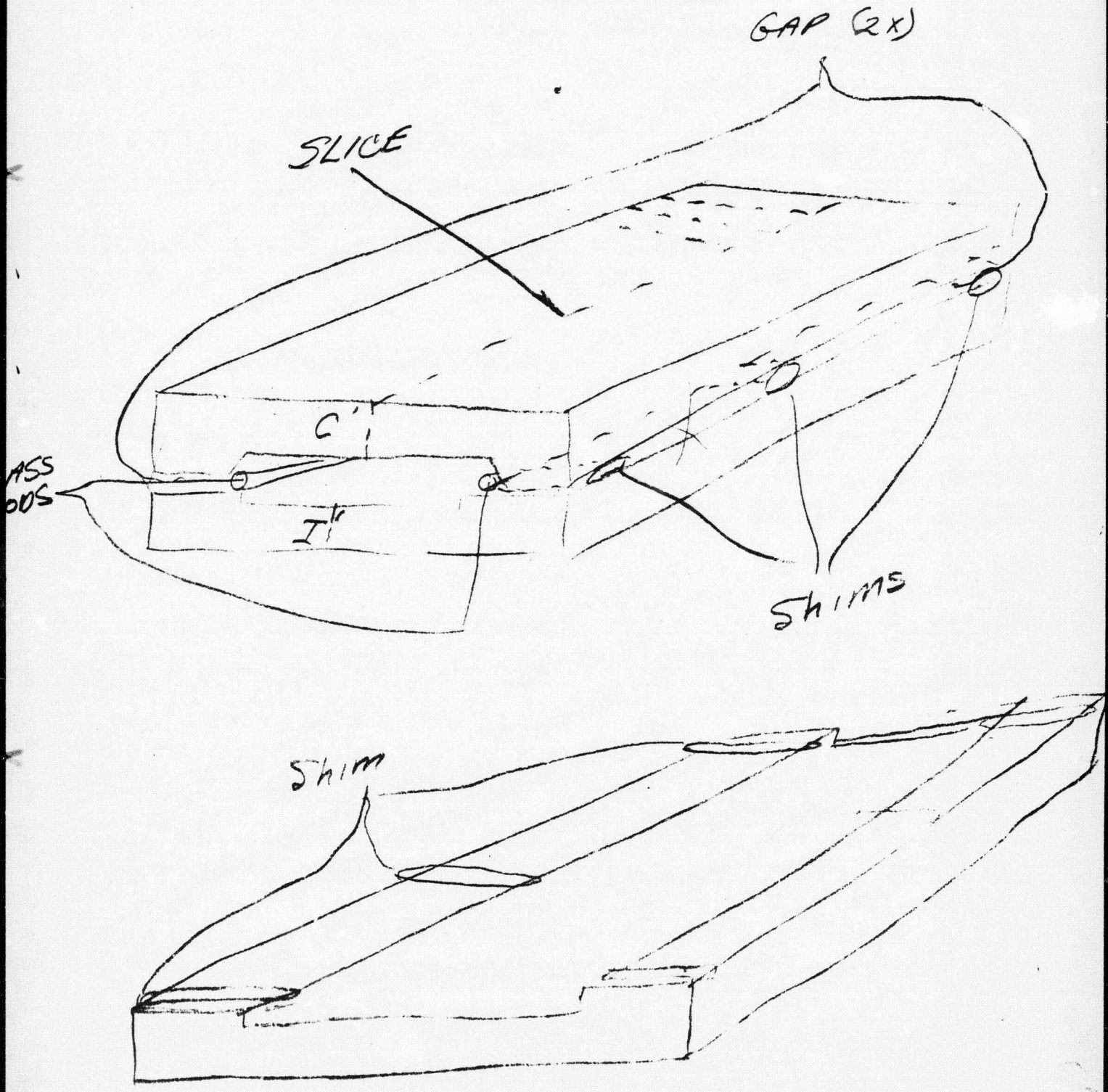
PLAINTIFF'S EXHIBIT 13.

U. S. Philips Corp. vs.
National Micronetics, Inc.
C. A. 71 Civ. 921 R. W.



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B. JACOBS 3/27 1973

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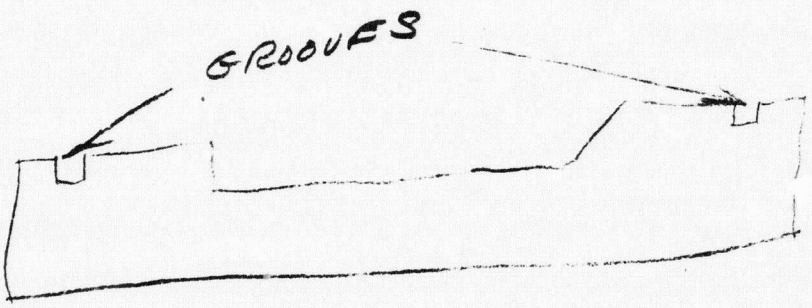
PLAINTIFF'S EXHIBIT 14.




PLAINTIFF'S EXHIBIT 14

PENCAD - Bayonne, N. J.

U. S. Philips Corp. vs.
National Micronetics, Inc.
C. A. 71 Civ. 921 R. W.

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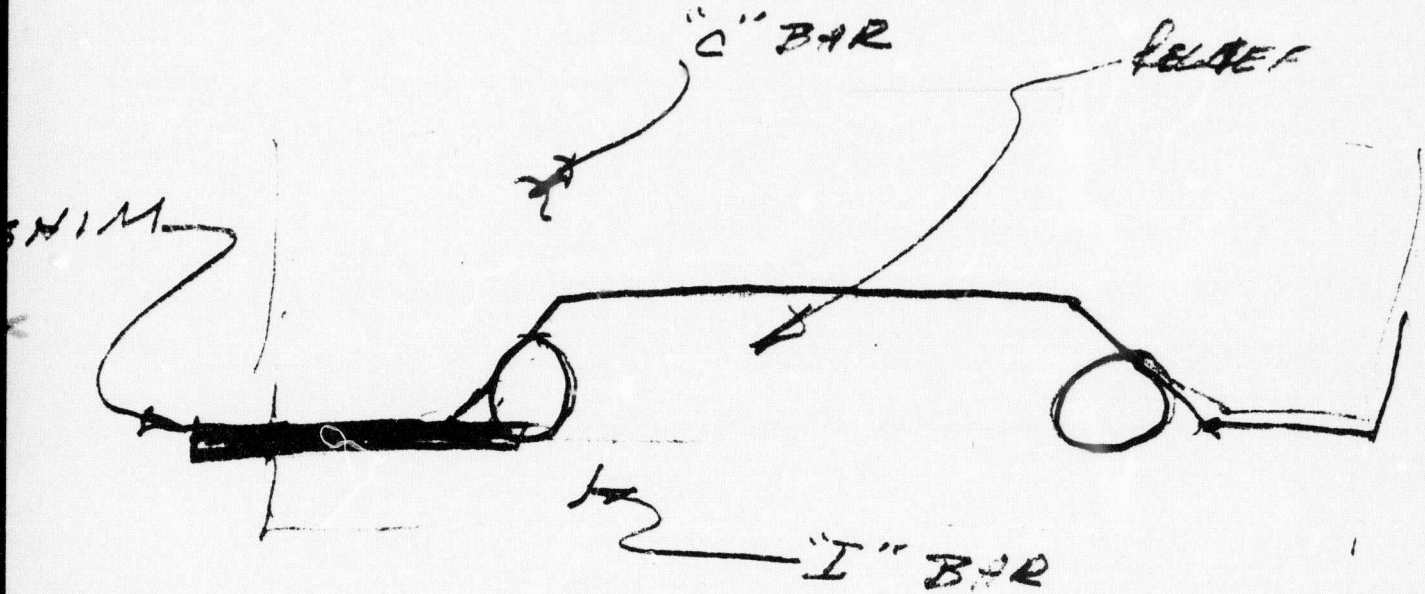
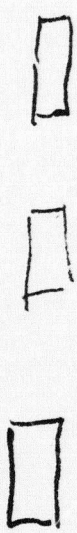
PLAINTIFF'S EXHIBIT 37.



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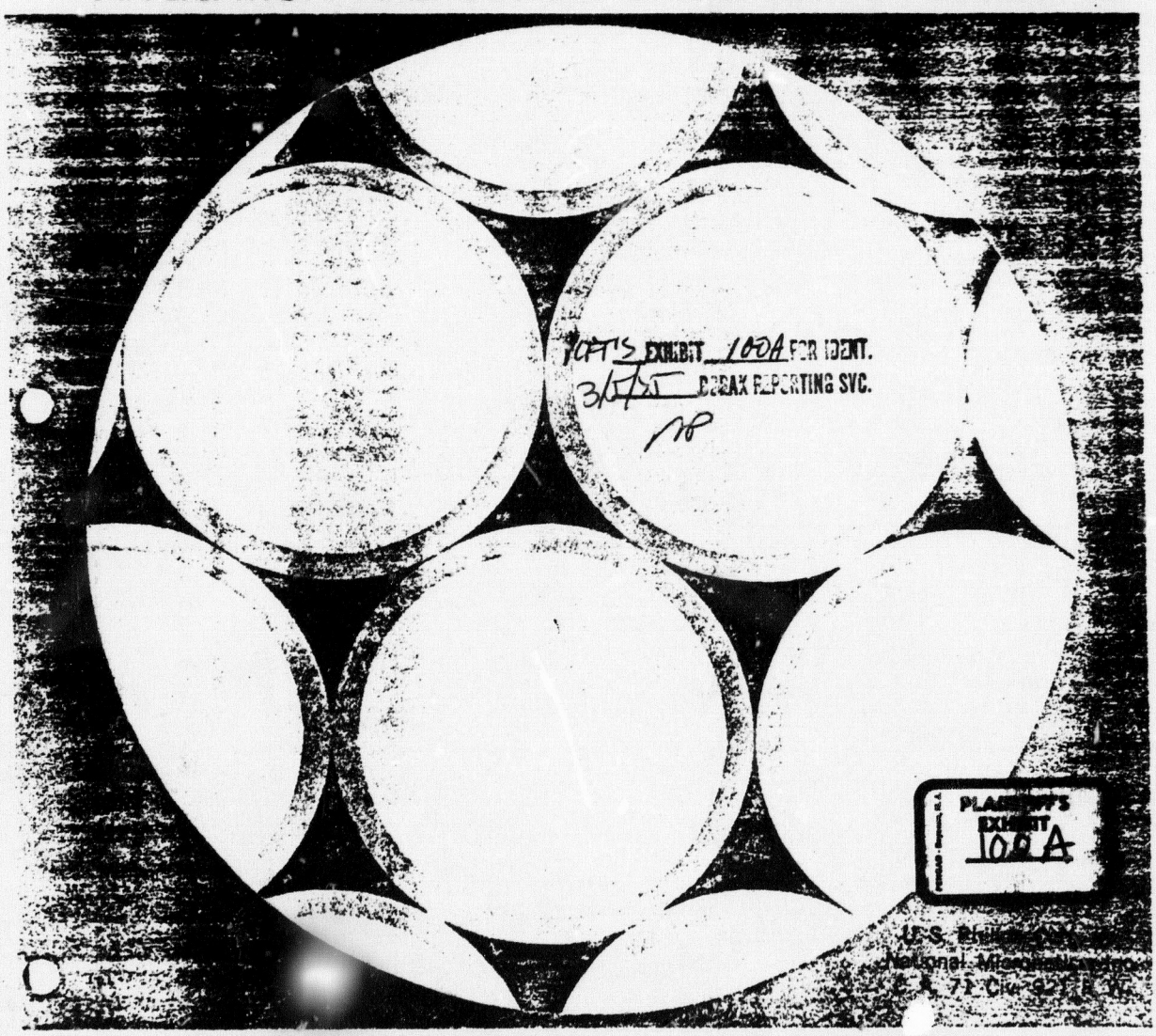
B. JACOBS 3/27 1973

PLAINTIFF'S EXHIBIT 100A.

FERROXCUBE ENGINEER

Vol. 6
No. 2
MAY
1964

# APPLICATION AND DESIGN OF INDUCTIVE FERRITES



PLT'S EXHIBIT 100A FOR IDENT.
3/5/65 DORAN REPORTING SVC.

PLAINTIFF'S EXHIBIT 100A

U.S. ... National Microfilm ... C.A. 71 Civ. 621 ...

## STANDARD WINDINGS FOR "P" TYPE POT CORES

FERROXCUBE CORPORATION OF AMERICA, SAUGERTIES, NEW YORK

PLAINTIFF'S EXHIBIT 100A

# NEWS FROM FERROXCUBE

### Flying Disc Recording Heads

Ferroxcube, through years of experience in ferrite technology and extensive research in the field of disc recording, is first to offer a mass produced ferrite flying disc recording head that provides superior electrical and mechanical performance at lower customer cost. Packing densities up to 1500 bits per inch are obtainable at 1500 inches per second. Nominal read output voltage is 45 mv peak-to-peak. Designed for use with plated recording discs, this new head is available in models with 1 to 12 tracks, each 10 mils wide.

The use of extremely high-density ferrite, 5.32 grams per cubic centimeter, provides an unexcelled gap definition. Gaps are bonded by means of a patented molten-glass bonding process. This process assures high mechanical rigidity and preservation of gap definition. Extended operating temperature ranges result from equal temperature coefficients of the ferrite, glass, and case materials. Ask for Bulletin 1004.

### 180 Nanosecond Coincident Current Planes and Stacks

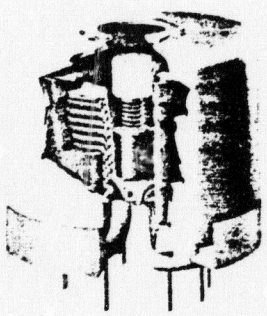
One microsecond read/write times are now possible with coincident current, ferrite memory planes and stacks. This extremely high speed has been made possible through a new Ferroxcube development: 20 mil, 180 nanosecond cores. The fast switching speed of this core combined with reduced plane and stack dimensions for lowered drive impedances and shorter winding lengths provide unexcelled ferrite memory performance.

Typical electrical specifications for these core planes and stacks include and undisturbed "one" output voltage of 53 mv and a disturbed "zero" output of only 6 mv. The full write current requirement is nominally 870 ma.

Planes and stacks are available in various bit and word configurations to meet virtually every application requirement. For complete details, ask for bulletin 831.

### New Pot Core Hardware

A new line of adjustors and printed circuit, can-type hardware for ferrite pot cores is available from Ferroxcube. These adjustors offer a tuning accuracy of better than 0.1% as well as a new degree of permanence after adjustment and provide an inductance increase of approximately +12% over the pre-adjustment ($A_L$) value of the pot core.



Designed for standard 0.1" printed circuit mounting centers and/or for bushing mounting, this hardware provides extremely high electrical stability for the final core assembly. Both adjustors and hardware have been tested under environmental conditions of MIL-STD-202 (Method B) and have proven superior in performance to other types.

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PLAINTIFF'S EXHIBIT 130.

IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF NEW YORK

U. S. Philips Corp. vs.
National Micronetics, Inc.
C. A. 71 Civ. 921 R. W.

| | |
|---|---|
| U. S. PHILIPS CORPORATION,<br><br>Plaintiff,<br><br>v.<br><br>NATIONAL MICRONETICS INC., ET AL.,<br><br>Defendants,<br><br>v.<br><br>NORTH AMERICAN PHILIPS CORPORATION, and N. V. PHILIPS GLOEILAMPENFABRIEKEN,<br><br>Counter-Defendants. | Civil Action No.<br><br>71 C 921 (RW) |

PROFESSIONAL BIOGRAPHY OF
OTTO KORNEI

Background and Training

Mr. Kornei is a native of Vienna, Austria and attended primary and secondary schools there. In 1925, he was awarded a degree corresponding to that of Master of Science in Electrical Engineering by the Vienna Institute of Technology. Subsequently, Mr. Kornei attended the Institute of Technology in Berlin which in about 1930 awarded him an essentially corresponding degree.

PLAINTIFF'S EXHIBIT 130

Professional Career

Shortly after obtaining his first degree, Mr. Kornei became engaged in the field of picture transmission by broadcasting and, in this connection made his first acquaintance with the field of recording. From 1929 to 1936 Mr. Kornei worked for "TOBIS" (Tonbildsyndikat) in Berlin, the organization which held and licensed world-wide patents on sound motion pictures. With this organization his work dealt with sound recording on film as well as on magnetic media and phonograph discs. During this period Mr. Kornei had occasion to meet with other European workers in the field of magnetic recording, including Eduard Schüller and Von Braunühl, and to discuss with them their field of mutual interest. During this same period Mr. Kornei was invited to give a number of talks to local technical associations on his work, although none of these was published.

Political events in Europe interrupted Mr. Kornei's career in 1936 and resulted in his coming to the United States in 1938. His first position in this country was as a consultant to Mr. Chester Carlson, who today is celebrated as the originator of xerography. When Mr. Carlson's money ran out after six months of this relationship, Mr. Kornei accepted a position with the Brush Development Company in Cleveland, Ohio, a manufacturer, among other things, of magnetic recording

equipment.

At Brush, Mr. Kornei worked on magnetic recording as well as phonographic disc recording. His work in magnetic recording concentrated in the area of magnetic heads and magnetic recording media. He was manager of a developmental group concerned with magnetic recording. In addition to concerning himself with basic design of magnetic heads he also travelled in connection with the marketing and sales of these products, as a result of which he met many of the workers in the computer field interested in magnetic recording, including Howard Aiken, Morris Rubinoff, Benjamin Moore and Julian Bigelow.

Brush Development Company changed its name to Clevite Corporation in 1955 or 1956,which in turn was merged into Gould, Inc. in 1972. While at Brush, Mr. Kornei supervised eight to ten people,somewhat more than half of whom were college graduates.

In 1956, Mr. Kornei left Brush to assume a position with IBM where he remained until reaching mandatory retirement age in 1968. At IBM Mr. Kornei worked on digital magnetic recording, first in that company's Poughkeepsie, New York installation and later at their San Jose, California facility, where he held the title of Manager of Storage Technology and Advance Technology. In that position, Mr. Kornei supervised from three to twenty people.

PLAINTIFF'S EXHIBIT 130

For a period of time after his retirement, Mr. Kornei served as a half-time consultant for IBM. He has been a consultant for other clients, including the successor to Brush Development Company. He has appeared as an expert in a suit between Control Data Corporation and Sperry Rand Corporation, as a technical witness in a suit between IBM and Xerox, and as a technical expert in a suit between 3M and Technical Tape Corp.

Awards and Honors

In 1960, Mr. Kornei was elected Honorary Member of the Audio Engineering Society.

In 1968, Mr. Kornei was advanced to the rank of Fellow by the Institute of Electrical and Electronic Engineers, his citation stating that this honor is "for fundamental and extensive contributions to magnetic recording technology for video and audio applications, as well as creative contributions to the beginnings of xerography."

Publications

1. On the Playback Loss In The Reproduction Of Phonograph Recrods, Journal of the Society of Motion Picture Engineers, Vol. XXXVII, December 1941.

2. Frequency Response of Magnetic Recording, Electronics, August 1947.

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3. Survey Of Magnetic Recording, Proceedings Of A Symposium On Large Scale Digital Calculating Machinery, Annals of the Harvard Computation Laboratory, Vol. XVI, 1948.

4. Trends And Developments In Magnetic Recording Heads, Brush Strokes, March 1952.

5. Structure And Performance Of Magnetic Transducer Heads, Journal of the Audio Engineering Society, Vol. 1, No. 3, July 1953.

6. Survey Of Flux-Responsive Magnetic Reproducing Heads, Journal of the Acoustical Society of America, Vol. 27, No. 3, May 1955, and Journal of the Audio Engineering Society, Vol. 2, No. 3, July 1954.

7. Magnetic Head Has Megacycle Range, Electronics, Nov. 1956.

8. A Magnetic Head For The Megacycle Range, IRE Convention Record, 1956.

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United States

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PLAINTIFF'S EXHIBIT 130

| Number | Title | Filing Date | Issue Date |
|---|---|---|---|
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| 2,343,417 | Phonograph Pickup | 11/16/1942 | 3/7/1944 |
| 2,370,176 | Means and Method for Measuring Time Intervals | 6/22/1942 | 2/27/1945 |
| 2,395,127 | Time Measuring Instrument | 4/19/1944 | 2/19/1946 |
| 2,497,675 | Indicating Device with Automatic Zero Adjustment | 10/30/1946 | 2/14/1950 |
| 2,513,653 | Magnetic Record Transducing Head | 1/22/1947 | 7/4/1950 |
| 2,521,635 | Image Retaining System | 11/8/1945 | 9/5/1950 |
| 2,523,576 | Ring-Type Magnetic Record-Transducing Head | 8/2/1946 | 9/26/1950 |
| 2,535,498 | Erasing Head and Apparatus for Magnetic Recorders | 11/7/1947 | 12/26/1950 |
| 2,546,310 | Method of Growing Crystals | 3/21/1945 | 3/27/1951 |
| 2,547,948 | Process for Forming Magnetic Record Members from a Papermaking Fiber Slurry | 7/21/1947 | 4/10/1951 |
| 2,594,934 | Erasing Head for Magnetic Record Members | 1/20/1950 | 4/29/1952 |
| 2,631,855 | Magnetic Recording and Reproducing | 9/27/1947 | 3/17/1953 |
| 2,643,130 | Multilayer Magnetic Record Member | 11/2/1949 | 6/23/1953 |
| 2,683,856 | Magnetic Electric Transducer | 1/24/1951 | 7/13/1954 |
| 2,704,789 | Multi-Channel, Flux Responsive, Magnetic Reproducer Head Unit | 11/6/1953 | 3/22/1955 |

PLAINTIFF'S EXHIBIT 130

| Number | Title | Filing Date | Issue Date |
|---|---|---|---|
| 2,711,945 | Magnetic Transducer Head for High Frequency Signals | 3/4/1953 | 6/28/1955 |
| 2,743,507 | Method of Making Magnetic Transducer Heads | 6/8/1951 | 5/1/1956 |
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| 2,866,011 | Magnetic Transducer Head | 7/13/1954 | 12/23/1953 |
| 2,905,770 | Flux Responsive Magnetic Reproducer Head | 1/19/1956 | 9/22/1959 |
| 2,917,589 | High Efficiency Magnetic Recording and Reproducing Head | 1/7/1955 | 12/15/1959 |
| 2,991,511 | Method of Making Multi-channel Magnetic Transducer Heads | 12/20/1955 | 7/11/1961 |
| 3,004,325 | Method of Making a Magnetic Head for Recording Reproducing | 10/21/1952 | 10/17/1961 |
| 3,065,311 | Magnetic Transducer | 9/15/1958 | 11/20/1962 |
| 3,245,062 | Magnetic Annealing for Information Storage | 11/15/1960 | 4/5/1966 |
| 3,284,785 | Magneto-Optic Readout Detector | 7/16/1963 | 11/8/1966 |
| 3,343,174 | Magnetic Annealing for Information Storage | 11/15/1960 | 9/19/1967 |
| 3,558,338 | Image Development System (as a co-inventor) | 3/25/1968 | 1/26/1971 |

PLAINTIFF'S EXHIBIT 130

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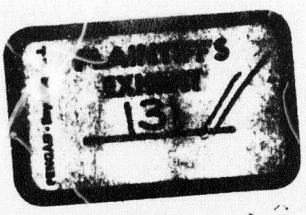
PLAINTIFF'S EXHIBIT 131A-D

A. Certificate of Election of Otto Kornei as Fellow by Institute of Electrical and Electronic Engineers (PX 131A)

B. 1968 Fellow Awards by IEEE (PX 131B)

C. Otto Kornei Publications (PX 131C)

D. Otto Kornei Patents (PX 131D)




U. S. [illegible]
National Micronetics, Inc.
C. A. 71 Civ. 921 R. W.

U. S. Philips Corp. vs.
National Micronetics, Inc.
C. A. 71 Civ. 921 R. W.

PLAINTIFF'S EXHIBIT 132.

FIG. 1

## BASIC ELEMENTS OF MAGNETIC RECORDING

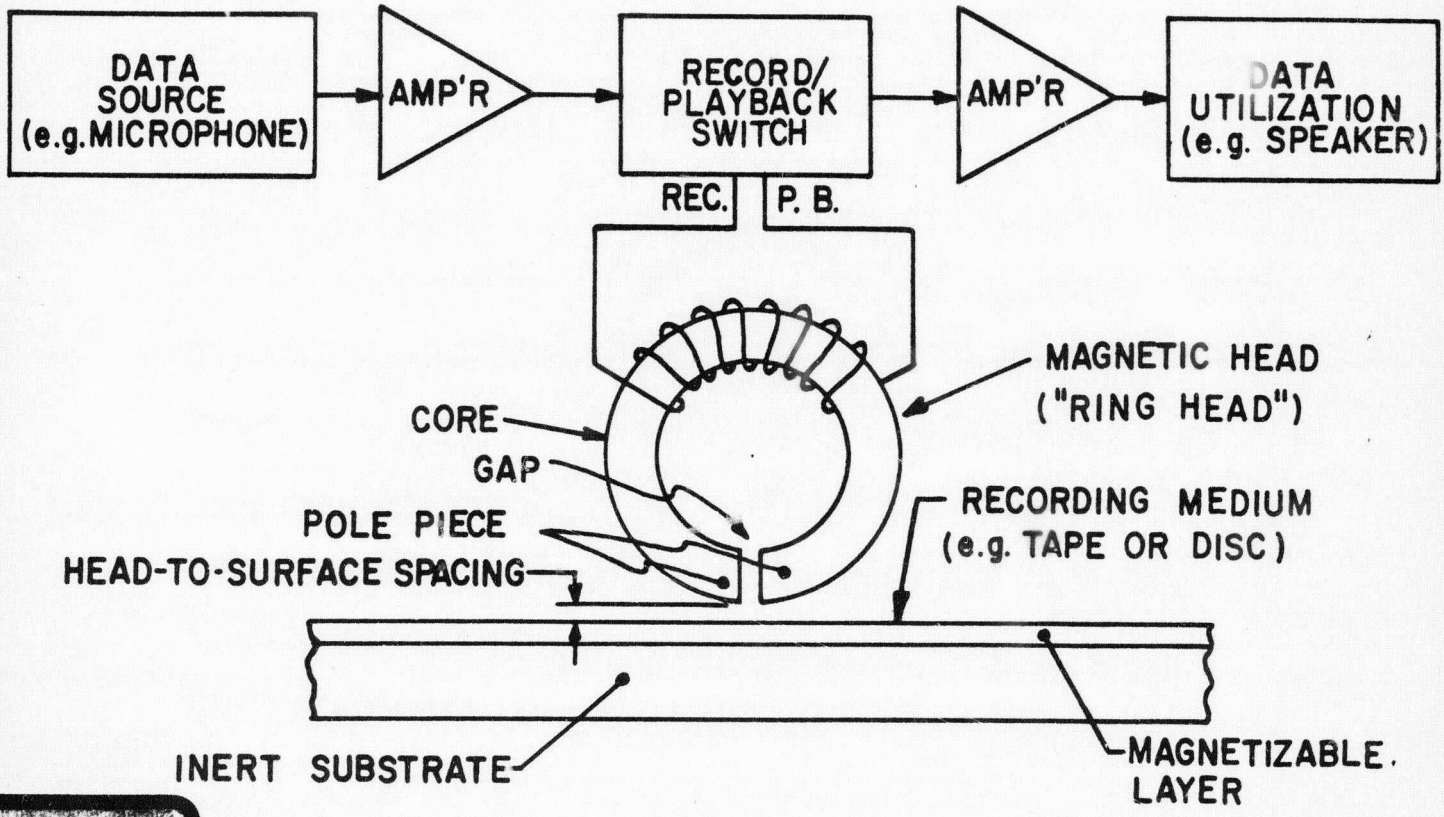



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FIG. 2

## MAGNETIC FIELD NEAR RECORDING GAP

S. Philips Corp. vs.
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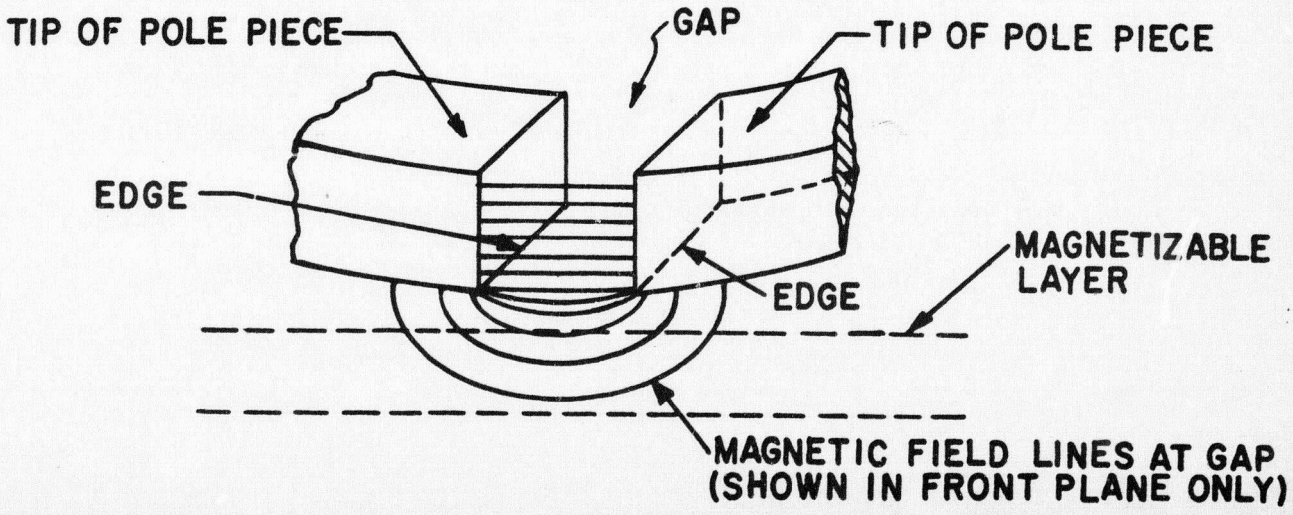
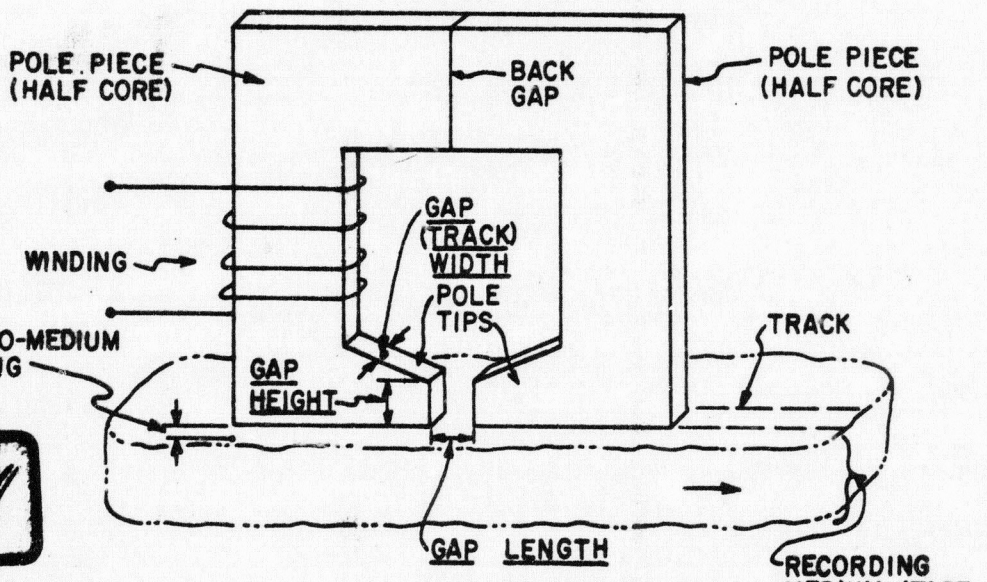


PLAINTIFF'S EXHIBIT 134.

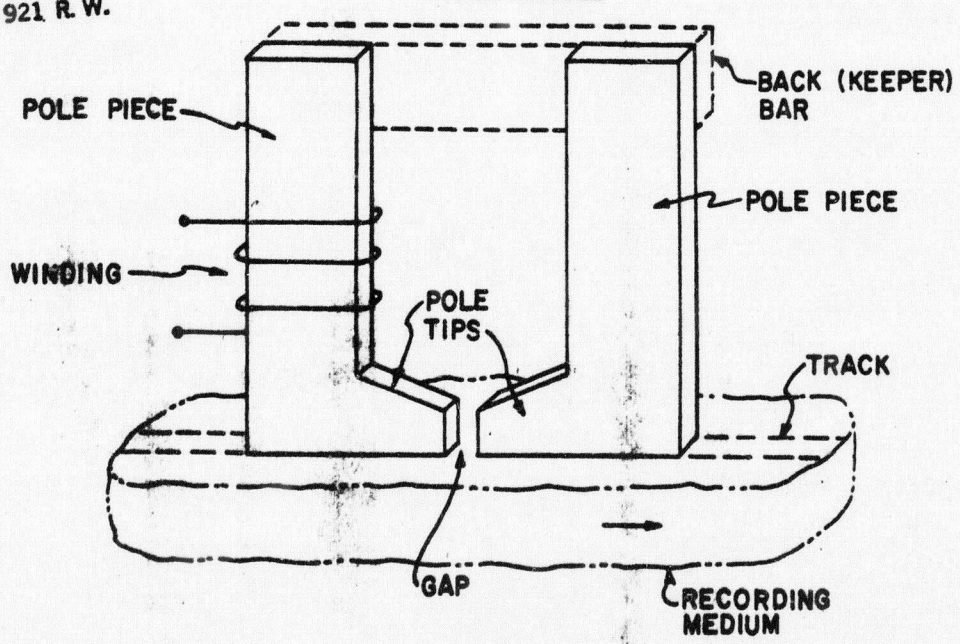
# FERRITE CORE STRUCTURE & TERMINOLOGY

A. CLOSED CORE




U. S. Philips Corp. vs. National Micronetics, Inc. C. A. 71 Civ. 921 R. W.

B. OPEN CORE



PLAINTIFF'S EXHIBIT 141.

March 6, 1962 S. DUINKER ETAL 3,024,318

GLASS GAP SPACER FOR MAGNETIC HEADS

Filed Sept. 11, 1956

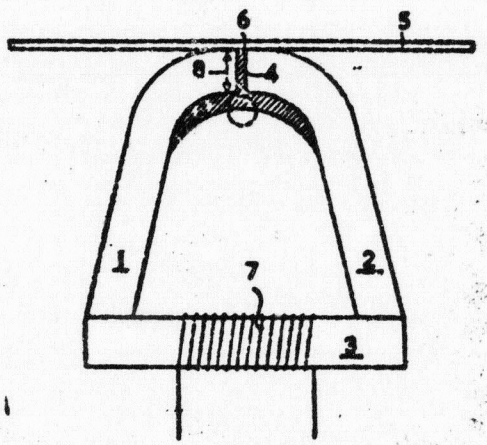



FIG.1

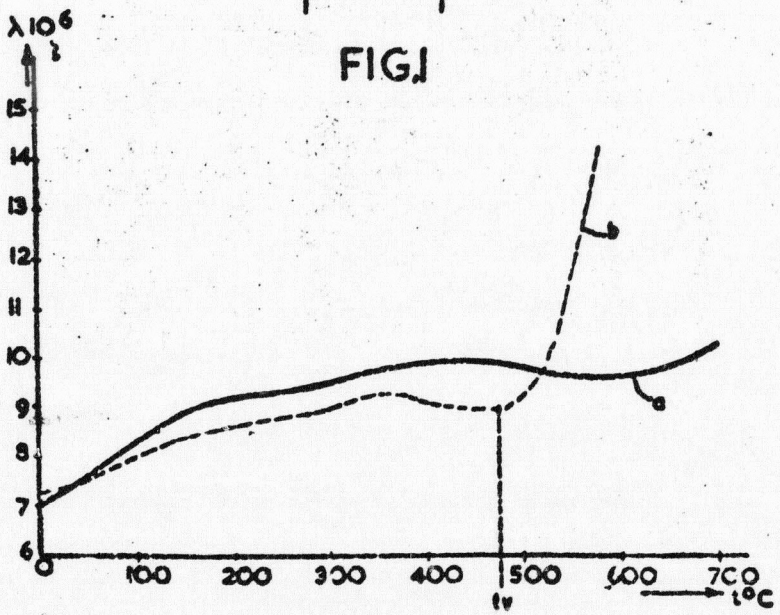



FIG.2

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PLAINTIFF'S EXHIBIT 141

U. S. Philips Corp. vs.
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PLAINTIFF'S EXHIBIT 141

United States Patent Office

3,024,318
Patented Mar. 6, 1962



3,024,318

# GLASS GAP SPACER FOR MAGNETIC HEADS

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Filed Sept. 11, 1956, Ser. No. 609,284
Claims priority, application Netherlands Oct. 4, 1955
4 Claims. (Cl. 179—100.2)

The present invention relates to annular heads for magnetic recording and/or reproducing apparatus. More particularly, the invention is concerned with such heads which comprise at least two circuit parts of sintered ferromagnetic oxide material between which an effective gap is formed and includes the improvement of filling said gap with glass, the glass serving as non-magnetic material to protect the effective gap and also to join the two circuit parts to one another mechanically.

The term "annular head for a magnetic recorder" as used herein is to be understood to mean a magnetic recorder head, the circuit parts of which are so shaped that, when assembled, they enclose a central space in which one or more coils can be arranged.

Generally, the non-magnetic material which fills the effective gap, i. e. the gap past which the carrier of the magnetic recordings is guided, consists of a foil-shaped spacing plate made of a non-magnetic metal, for example beryllium copper, the thickness of which fulfils the requirements to be satisfied by the width of the gap. In the present state of the art with respect to magnetic recordings, these requirements have become comparatively exacting and the disadvantages attendant on the use of such distance foils during manufacture are becoming increasingly marked. Even discounting the manufacturing difficulties, however, such plates having a thickness of a few microns are very vulnerable owing to their size and, in addition, any burrs produced on a plate become comparatively significant in ensuring a good connection of the circuit parts.

In order to obviate these disadvantages, it has already been suggested to use as the non-magnetic material synthetic substances which are provided in the liquid state and then are hardened and which also mechanically connect together the two circuit parts. As examples of such materials we may mention ethoxulin resin and poly-ester resin.

Since the material is provided in the liquid state, it is enabled to fill up the space between the surfaces bounding the effective gap, so that a good connection is automatically ensured. In addition, after hardening of the material, the two circuit parts are joined to one another to a certain extent, the ultimate fixation, however, requiring the use of other means, such as pressure discs or lateral springs.

However, the use of these synthetic substances entails a number of disadvantages. The use of further means to ensure the ultimate fixation has already been mentioned. It is also found that the synthetic substances, due to their low wear resistance, are comparatively rapidly worn off during operation, in which a comparatively large amount of heat is generated by the friction between the carrier of the magnetic recordings and the magnetic recorder head, so that the edges of the gap are deprived of the protective action of the non-magnetic material in the gap. It has been found that the unprotected edges of the ferrite are chipped by the wearing action of the magnetic recording carrier. It is also very difficult if not impossible to produce small gap-widths (of the order of magnitude of a few microns and to adjust the desired thickness).

In order to avoid these difficulties, it has been proposed to use glass as the non-magnetic material. Thus part of



the said difficulties, i. e. those with respect to achieving small widths and adjusting the desired thickness, are actually obviated. However, the chipping of the edges of the ferrite is found not to be avoided in the proposed magnetic recorder head.

According to the invention, this last disadvantage is obviated in that as the non-magnetic material use is made of a glass the coefficient of expansion of which, for the temperature at which the magnetic recorder head is used, is equal as far as possible to the corresponding coefficient of expansion of the ferromagnetic material from which the said circuit parts of the magnetic recorder head are made, for example does not differ therefrom by more than 5%.

The invention is based on the recognition of the fact that, even if in the finished product there is a good adherence between the ferromagnetic circuit parts of the magnetic recorder head and the glass, for which adherence a difference in the coefficients of expansion of at least 30% is permissible, the differences in the coefficients of expansion introduce tensions in the glass and in the ferrite owing to which the ferrite edges of the effective gap will show chipping under the action of the mechanical forces exerted by the magnetic recording carrier in operation. It is also found that these tensions give rise to difficulty in manufacture when polishing the pick-up ferrite surface of the magnetic recorder head. Truly flat-ground pick-up surfaces in the proximity of the air-gap are unattainable in practice.

The invention also relates to a method of manufacturing magnetic recorder heads in accordance with the invention. According to the invention, a glass foil is interposed between the polished ferrite gap surfaces which has a coefficient of expansion at the said temperature which is as far as possible equal to that of the ferromagnetic material, the thickness of the foil exceeding the ultimately desired gap-width by a few percents, after which the assembly is heated to a temperature lying in the softening range of the glass and subsequently is compressed at a temperature lying in this softening range under a pressure such that, after hardening of the glass, the correct gap-width is achieved.

Obviously the magnitude and the time of action of the force depend upon the properties of the glass used, upon the cross-sectional area of the magnetic circuit at the effective gap and also upon the temperature at which the force is exerted.

It has been found that, when using sintered ferromagnetic oxide material for the circuit parts of the magnetic recorder head, the glass adherence obtained has a strength which is of the same order of magnitude as that of the circuit parts themselves.

The invention will now be described in detail with reference to the figures of the accompanying drawing, in which:

FIG. 1 shows an annular magnetic recorder head in accordance with the invention, and

FIG. 2 is a curve illustrating the invention.

In FIG. 1, an annular magnetic recorder head comprises two identical circuit parts 1 and 2 and a closing yoke 3. The air-gap 4 formed between the circuit parts 1 and 2 past which the carrier of the magnetic recording 5 is moved, is filled with a non-magnetic material 6, in this case with glass, the coefficient of expansion of which at the above-mentioned temperature is substantially equal to that of the material from which the circuit parts 1, 2 and 3 are made. In the embodiment shown, a coil 7 is provided on the circuit part 3. In the embodiment shown, the glass which is used as the non-magnetic material is not restricted to the air-gap 4, but also fills part of the central space produced by the circuit parts 1, 2 and 3. Such an additional amount of glass imparts an additional rigidity

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to the circuit in the vicinity of the air-gap 4 and also enables the height of the air gap designated 8 in the figure to be reduced by grinding to a desirable very small value without the risk of a material decrease of the strength of the circuit in the proximity of the air-gap.

This additional amount of glass can be provided in a simple manner in that, prior to heating, a glass rod of the same kind of glass which is used as the non-magnetic material is arranged at the inner side of the ferromagnetic circuit parallel to and in close proximity to the air-gap (this rod is shown diagrammatically in FIG. 1 by a broken circle). During heating, the glass spreads to form a layer as shown in FIG. 1.

An example of a suitable combination is:

FERROMAGNETIC OXIDE MATERIAL

*Composition*

| | Mol percent |
|---|---|
| MnO | 24.1 |
| ZnO | 23.4 |
| FeO | 2.3 |
| $Fe_2O_3$ | 48.8 |
| $SiO_2$ | 1.3 |

Coefficient of expansion: $9.3\times10^{-6}$ between 0° C. and 40° C.

GLASS

*Composition*

| | Percent by weight |
|---|---|
| $SiO_2$ | 56.2 |
| $Na_2O$ | 7.6 |
| $K_2O$ | 4.5 |
| PbO | 30.0 |
| $Al_2O_3$ | 1.2 |
| $Sb_2O_3$ | 0.3 |
| MnO | 0.25 |

Coefficient of expansion: $9.2\times10^{-6}$ between 0° C. and 40° C.

As another example we may mention:

FERROMAGNETIC OXIDE MATERIAL

*Composition*

| | Mol percent |
|---|---|
| NiO | 17.5 |
| ZnO | 33.2 |
| $Fe_2O_3$ | 49.0 |
| $SiO_2$ | 0.3 |

Coefficient of expansion: $7.1\times10^{-6}$ between 0° C. and 40° C.

GLASS

*Composition*

| | Percent by weight |
|---|---|
| $SiO_2$ | 72.5 |
| $Na_2O$ | 11.5 |
| CaO | 10.0 |
| MgO | 3.3 |
| $Al_2O_3$ | 2.5 |
| $K_2O$ | 0.2 |

Coefficient of expansion $7.3\times10^{-6}$ between 0° C. and 40° C.

Tests have confirmed that, provided the requirement with respect to the coefficient of expansion is satisfied, any other combination of a ferromagnetic oxide material and a glass (for example lime-glass, lead-glass, baryte glass; this latter kind of glass contains from 10% to 30% by weight of BaO) produces satisfactory results. It should be noted that the term "Glass" is used herein in the broadest sense of the word. Compositions which frequently are referred to as enamel or glaze can be used for the desired object. As an example we may mention an enamel of the following composition:

| | Percent by weight |
|---|---|
| PbO | 80 |
| $B_2O_3$ | 16 |
| ZnO | 4 |



Coefficient of expansion: $10.5\times10^{-6}$ between 0° C. and 40° C.

It has been found that an enamel of this composition can be combined satisfactorily with a ferromagnetic oxide material of, for example, the following composition:

| | Mol percent |
|---|---|
| MnO | 30 |
| ZnO | 18 |
| $Fe_2O_3$ | 52 |

Coefficient of expansion: $10.0\times10^{-6}$ between 0° C. and 40° C., or of the following composition:

| | Mol percent |
|---|---|
| MnO | 37 |
| ZnO | 10 |
| $Fe_2O_3$ | 53 |

Coefficient of expansion: $10.2\times10^{-6}$ between 0° C. and 40° C.

However, if the ferromagnetic oxide material of the second example having a coefficient of expansion of $7.1\times10^{-6}$ is combined with the glass of the first example having a coefficient of expansion of $9.2\times10^{-6}$, although a very firm adherence is achieved between the glass and the circuit parts, machining the pick-up ferrite surface proves to give rise to great difficulties, whilst it is also found that, after operation for a few hours, the pick-up ferrite surface of the head is heavily damaged and completely unsuited for further operation.

The same applies to an even higher extent to the combination of the ferromagnetic oxide material of the first example and the glass of the second example.

It has been found that machining the magnetic recorder head, in this case polishing the pick-up ferrite surfaces, is materially facilitated and also that the resistance of the ferrite edges of the effective gap to the mechanical forces exerted by the carrier of the magnetic recordings during operation is improved, if the two coefficients of expansion are as far as possible equal to one another not only at the temperature at which the magnetic recorder head is used, but also over the entire temperature range lying between the temperature at which the magnetic recorder head is used and the temperature at which the glass begins to soften.

When the coefficients of expansion are equal to one another at the temperature at which the magnetic recorder head is used (with a tolerance of 5%), the tensions occurring in the glass are small thus preventing the production of strains in the ferrite which would also tend to facilitate chipping of the ferrite edges of the gap by the mechanical forces exerted by the operation of the magnetic recording carrier; when the coefficients of expansion are equal through the entire above temperature interval (with a tolerance of 10% except at the temperature at which the magnetic recorder head is used) these tensions prove to be substantially entirely eliminated.

FIG. 2 illustrates an example of a suitable combination of materials, the coefficients of expansion of which show satisfactory agreement in the said temperature interval.

In this figure, the (linear) coefficient of expansion of a sintered ferromagnetic oxide material of the following composition (see the above second example):

| | Mol percent |
|---|---|
| NiO | 17.5 |
| ZnO | 33.2 |
| $Fe_2O_3$ | 49.0 |
| $SiO_2$ | 0.3 |

is plotted as a function of the temperature $t$ in degrees C.

The curve showing the said relationship is designated $a$ in the figure.

In this figure the coefficient of expansion of a lime

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glass is also plotted as a function of the temperature, the glass having the following composition (see also the above second example):

| | Percent by weight |
|---|---|
| $SiO_2$ | 72.5 |
| $Na_2O$ | 11.5 |
| CaO | 10.0 |
| MgO | 3.3 |
| $Al_2O_3$ | 2.5 |
| $K_2O$ | 0.2 |

The curve showing this relationship is designated *b* in the figure. The temperature at which the glass becomes plastic is indicated by $t_s$. It will be seen from the figure that in the temperature range situated between the temperature at which the magnetic recorder head is used (room temperature) and the temperature at which the glass begins to change its state ($t_s$) the two coefficients of expansion are in very good agreement.

What is claimed is:

1. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising at least two circuit parts of sintered ferromagnetic oxide material with an effective gap between said circuit parts, said gap being filled entirely with a glass material mechanically joining and bonding to each other said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material having a coefficient of expansion substantially equal to the coefficient of expansion of said sintered ferromagnetic oxide material at the temperature at which the magnetic recorder head is used.

2. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising a least two circuit parts of sintered ferromagnetic oxide material with an effective gap between said circuit parts, said gap being filled entirely with a glass material mechanically joining and bonding to each other said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material having a softening temperature, said glass material also having a coefficient of expansion substantially equal to the coefficient of expansion of said sintered ferromagnetic oxide material throughout the entire temperature range lying between the temperature at which the magnetic recorder head is used and the temperature at which the glass begins to soften.

3. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising at least two circuit parts of sintered ferromagnetic oxide material having inner and outer surfaces with an effective gap between said circuit parts, said gap being filled entirely with a glass material mechanically joining and bonding to each other said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material and said circuit parts forming a closed annular space, part of said glass material extending into said space in contact with the inner surfaces of said ferromagnetic oxide material, said glass material having a coefficient of expansion substantially equal to the coefficient of expansion of said ferromagnetic oxide material at the temperature at which the magnetic recorder head is used.



4. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising at least two circuit parts of sintered ferromagnetic oxide material having inner and outer surfaces with an effective gap between said circuit parts, said gap being filled entirely with a glass material mechanically joining and bonding to each other said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material having a softening temperature, said glass material and said circuit parts forming a closed annular space, part of said glass material extending into said space in contact with the inner surfaces of said ferromagnetic oxide material, said glass material having a coefficient of expansion substantially equal to the coefficient of expansion of said ferromagnetic oxide material throughout the entire temperature range lying between the temperature at which the magnetic recorder is used and the temperature at which the glass begins to soften.


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April 19, 1966 H. P. PELOSCHEK ET AL 3,246,383

METHOD OF MANUFACTURING MAGNETIC HEADS WITH BONDING GAP-FILLING MATERIALS

Filed May 3, 1963

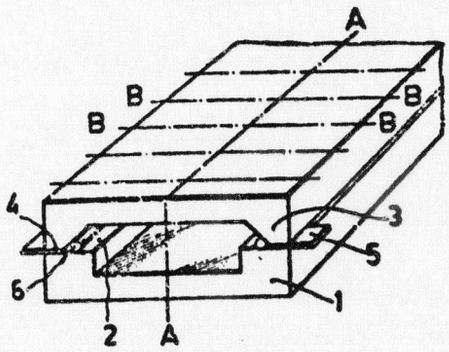


FIG.1

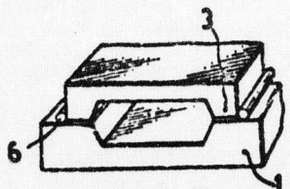


FIG.3

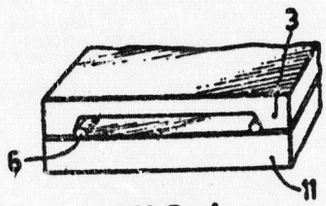


FIG.4

U. S. Philips Corp. vs.
National Micronetics, Inc.
C. A. 71 Civ. 921 R. W.

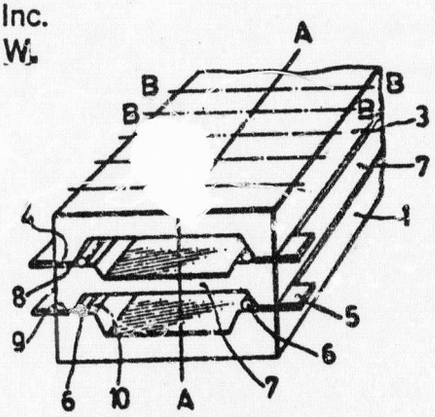


FIG.2

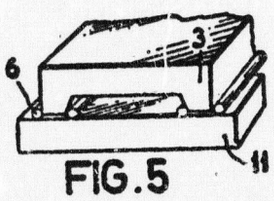


FIG.5

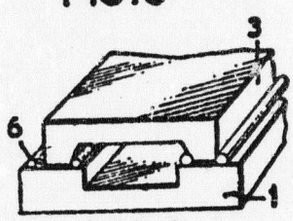


FIG.6

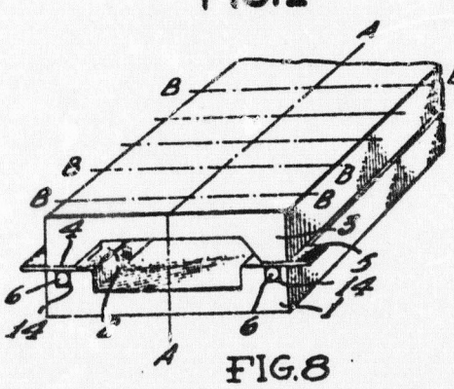


FIG.8

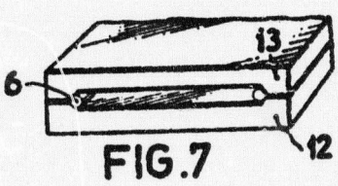


FIG.7

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PLAINTIFF'S EXHIBIT 144

United States Patent Office

3,246,383

Patented Apr. 19, 1966

1

3,246,383

# METHOD OF MANUFACTURING MAGNETIC HEADS WITH BONDING GAP-FILLING MATERIALS

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Filed May 3, 1963, Ser. No. 277,829

Claims priority, application Netherlands, May 8, 1962, 278,197; Jan. 29, 1963, 288,321

15 Claims. (Cl. 29—155.5)

The invention relates to a method of manufacturing parts of annular magnetic heads for recording, reproducing or erasing magnetic recordings. It relates in particular to such heads which comprise at least two circuit parts of sintered oxidic ferromagnetic material, a very short gap filled with nonmagnetic material being located between confronting surfaces of the circuit parts; the nonmagnetic material also serves to bond the circuit parts together. Magnetic heads with very short gaps having lengths varying between 1 and 20 microns are difficult to manufacture since close tolerances are usually imposed on the length of gap and the nonmagnetic material in the gap must have a good resistance to detrition and must be capable of being readily processed; in addition, the process of manufacture should be as economical and simple as possible. The gap material also must be as homogeneous as possible. It is a primary object of the invention to provide a method of manufacturing magnetic heads with very short gap lengths which is comparatively simple to perform while achieving close tolerances for gap length.

According to one aspect of the invention, at least two parts of sintered oxidic ferromagnetic material having gap-confronting surfaces are placed in confronting relationships with the inter-position of spacing members having a thickness equal to the desired gap length; then a quantity of glass or enamel in the form of grains, powder or a coherent rod or plate is placed adjacent to the gap or gaps thus formed, the maximum melting point of said glass or enamel being 900° C., after this, the assembly is heated up to the melting temperature of the glass or enamel and then, after cooling, the whole block is mechanically split into a number of head parts having the desired gap width.

In order to prevent the liquid enamel from flowing between the spacing members and the parts, according to an embodiment of the invention the parts may be pressed together with a slight pressure during heating.

According to another aspect of the invention, each of the parts is heated for a short period of time at a temperature of from 800–1000° C. before the surfaces are placed in confronting relationship. As a result of this the surfaces are thermally etched so that the bond of the glass or enamel to the surface is further improved.

In another embodiment, at least one of the gap-confronting surfaces is provided with a shallow groove in which the glass or enamel is laid against the gap or gaps.

The invention also comprises a magnetic head when manufactured by any one or more of the above methods.

In order that the invention may readily be carried into effect, certain embodiments thereof will now be described more fully, by way of example, with reference to the accompanying drawing, in which

FIG. 1 shows two channel-shaped circuit parts and one step in the process of manufacture;

FIG. 2 shows three circuit parts and the same step in the manufacturing process; and

FIGS. 3, 4, 5, 6, 7 and 8 show several other suitably-shaped parts together with alternative locations of the

2

nonmagnetic gap-filling and bonding material in the same step.

In the drawing, reference numeral 1 designates a channel-shaped part consisting of sintered oxidic ferromagnetic material which is provided with polished surfaces 2. A part 3, similarly shaped, having polished surfaces 4 which may have a smaller width than the surfaces 2, is placed on the part 1 with the interposition of spacing members 5 which have a thickness equal to the length of the desired gap. These spacing members may be made, for example, from mica or beryllium copper. Both parts 1 and 3, after polishing the surfaces 2 and 4 but before placing together, are preferably heated to 800–1000° C. for a short period of time, as a result of which the surfaces 2 and 4 are thermally etched. After placement of the parts, a rod 6 composed of enamel is laid on the surfaces 2 adjacent to the gap and then the assembly is heated under a slight pressure so that the enamel melts. As a result of the capillary action of the gap the liquid enamel is forced into the gap, a gap filling then being obtained which is entirely free from inclusions, for example air bubbles. After cooling, the block is sawed into parts along the lines A—A and B—B which may serve as parts of annular magnetic heads.

Good results were obtained with an enamel of the following compositon: (in percent by weight): $SiO_2$ 16%, $B_2O_3$ 14%, ZnO 10% and PbO 60%.

FIGURE 2 shows a block from which parts for multi-track magnetic heads may be obtained. The channel-shaped parts 1 and 3 in this case are not placed directly upon each other but an I-shaped part 7 is interposed which has polished surfaces 8 and 9, the surface 8 again having a larger width than the surface 4 but the surface 9 having a smaller width than the surface 10. In the same manner as described for FIGURE 1, the parts are bonded together and after the bonding they are split into separate parts. Of course, several intermediate members 7 may be used for co-action with more tracks.

FIGURES 3 to 6 show two parts 1 and 3 having cross-sections different from those shown in FIGURES 1 and 2. These parts also are bonded together in the manner described for FIG. 1. In this case the lower part 1 may be channel-shaped and may be wider than the upper part 3, the enamel then being placed on the outside (FIGURE 3); the lower part 11 may be flat and as wide as part 3, the enamel being placed on the inside (FIGURE 4), or the flat part 11 may be wider than the part 3, so that the enamel may be located both on the inside and the outside (FIG. 5).

In FIGURE 6, part 1 is again wider than part 3 and the gap-bounding surfaces are also wider. The enamel may be placed both on the outside and on the inside adjacent to the gap.

In FIGURE 7 the two parts 12 and 13 have the same dimensions and the gap-bounding surfaces are equal in width. The channel depth in both parts is so small that the rods may be placed on the inside adjacent to the gaps.

In the embodiment of FIG. 8, a groove 14 is provided in the two surfaces of part 1, the glass rod 6 being placed in groove 14.

As a fusible material, glass may be used instead of enamel. In addition, it is to be noted that the fusible materials need not be only in rod-form; they may, for example, take the form of powder, grains, a narrow plate, or the like. Regardless of the form of the fusible material, the action is the same: upon melting, the molten material is forced into the gap by capillary action.

While the invention has been described with respect to specific embodiments, modifications and variations thereof will be readily apparent to those skilled in the art without departing from the inventive concept, the scope of which is set forth in the appended claims.

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What is claimed is:

1. A method of manufacturing portions of magnetic heads composed of two magnetic circuit parts consisting of sintered oxidic ferromagnetic material and having confronting gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: placing spacing members having a thickness equal to the desired gap length at opposite ends of a first polished gap surface of one circuit part, placing a corresponding polished gap surface of a second circuit part on said spacing members in confronting relationship with said first surface thereby forming a gap between said surfaces, placing a quantity of nonmagnetic material adjacent to the gap, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gap by capillary action, and bonds the circuit parts together.

2. A method according to claim 1, wherein said nonmagnetic material is glass.

3. A method according to claim 1, wherein said nonmagnetic material is enamel.

4. A method according to claim 1, wherein pressure is applied to the assembly during the heating step.

5. A method of manufacturing portions of magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: heating the two circuit parts, cooling the two circuit parts, placing spacing members having a thickness equal to the desired gap length at opposite ends of a first polished gap surface of one circuit part, placing a corresponding polished gap surface of a second circuit part on said spacing members in confronting relationship with said first surface thereby forming a gap between said surfaces, placing a quantity of nonmagnetic material adjacent to the gap, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gap by capillary action, and bonds the circuit parts together.

6. A method of manufacturing portions of magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: placing spacing members having a thickness equal to the desired gap length at opposite ends of at least two polished gap surfaces of one circuit part, placing the corresponding polished gap surfaces of a second circuit part on said spacing members in confronting relationship with the gap surfaces of said one circuit part thereby forming gaps between said surfaces, placing a quantity of nonmagnetic material adjacent to the gaps, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gaps by capillary action, and bonds the circuit parts together, cooling the assembly, and then cutting the assembly along mutually perpendicular axes to form a plurality of head portions.

7. A method according to claim 6, wherein the circuit parts are heated and subsequently cooled prior to the placing of the spacing members.

8. A method according to claim 6, wherein said nonmagnetic material is glass.

9. A method according to claim 6, wherein said nonmagnetic material is enamel.

10. A method of manufacturing portions of magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having confronting gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: placing a polished gap surface of one circuit part in confronting relationship with a corresponding polished gap surface of a second circuit part, said surfaces being separated by a gap equal to the desired gap length, placing a quantity of nonmagnetic material adjacent to the gap, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gap by capillary action, and bonds the circuit parts together.

11. A method according to claim 10, wherein said nonmagnetic material is glass.

12. A method of manufacturing portions of magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having confronting gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: placing a polished gap surface of one circuit part in confronting relationship with a corresponding polished gap surface of a second circuit part, said surfaces being separated by a gap equal to the desired gap length, one of said surfaces having a shallow groove therein, placing a quantity of nonmagnetic material in said groove, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gap by capillary action, and bonds the circuit parts together.

13. A method of manufacturing portions of magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having confronting gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: heating the two circuit parts, cooling the two circuit parts, placing spacing members having a thickness equal to the desired gap length at opposite ends of a first polished gap surface of one circuit part, placing a corresponding polished gap surface of a second circuit part on said spacing members in confronting relationship with said first surface thereby forming a gap between said surfaces, one of said surfaces having a shallow groove therein, placing a quantity of nonmagnetic material in said groove, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gap by capillary action, and bonds the circuit parts together.

14. A method of manufacturing portions of magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having confronting gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: heating the circuit parts, cooling the circuit parts, placing a polished gap surface of one circuit part in confronting relationship with a corresponding polished gap surface of another circuit part, said surfaces being separated by a gap equal to the desired gap length, placing a quantity of nonmagnetic material adjacent to the gap, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gap by capillary action, and bonds the circuit parts together.

15. A method of manufacturing portions of magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having confronting gap surfaces with a gap therebetween filled with a nonmagnetic material bonding the circuit parts together, comprising: thermally etching the gap surfaces of the two cir-

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cuit parts, placing a polished gap surface of one circuit part in confronting relationship with a corresponding polished gap surface of another circuit part, said surfaces being separated by a gap equal to the desired gap length, placing a quantity of nonmagnetic material adjacent to the gap, said nonmagnetic material having a melting temperature below that of said ferromagnetic material, and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material melts, fills the gap by capillary action, and bonds the circuit parts together.




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JOHN F. CAMPBELL, *Examiner.*

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Feb. 26, 1963 M. CAMRAS 3,079,470

MAGNETIC TRANSDUCER HEAD

Filed Dec. 21, 1959 2 Sheets-Sheet 1

Fig. 1

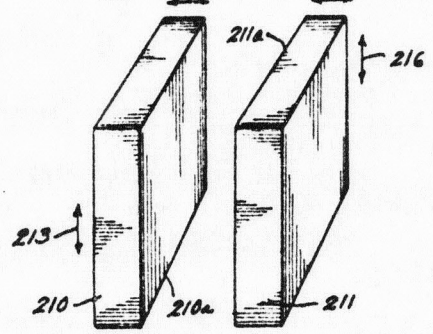


Fig. 2

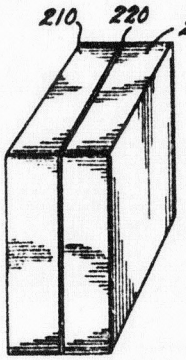


Fig. 3

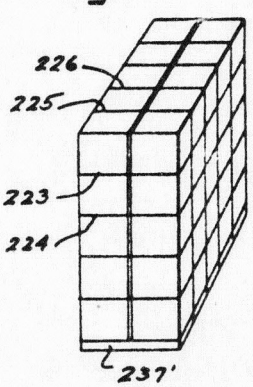


Fig. 4

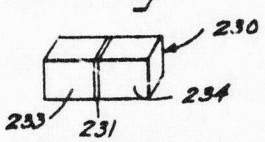


Fig. 5

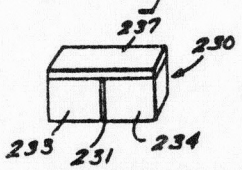


Fig. 6

Fig. 7

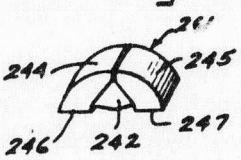


Fig. 8

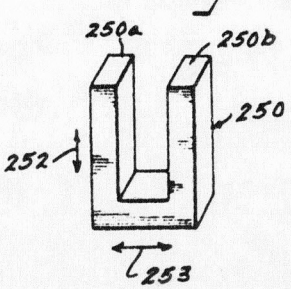


Fig. 9

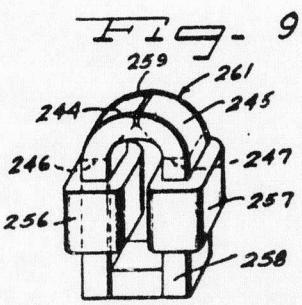


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Fig. 10

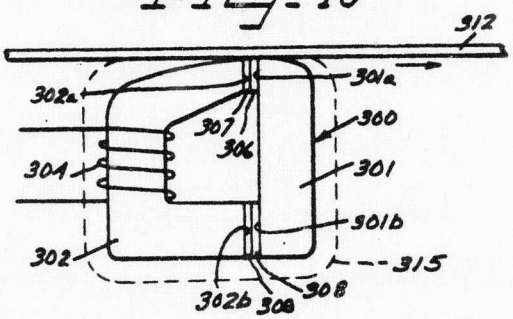



Fig. 11

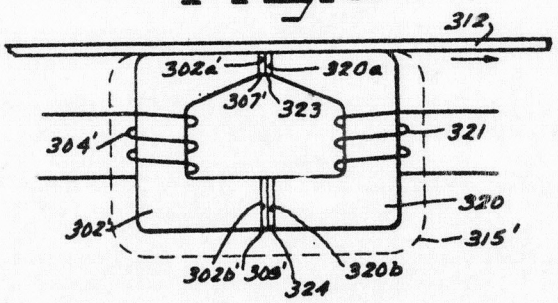
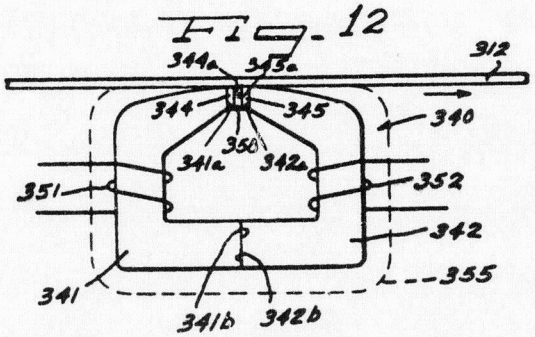



Fig. 12

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by Kill, Sperman, Marmi, Cass & Griffin Attys.

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United States Patent Office 3,079,470
Patented Feb. 26, 1963



3,079,470

# MAGNETIC TRANSDUCER HEAD

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Filed Dec. 21, 1959, Ser. No. 860,875
12 Claims. (Cl. 179—100.2)

This invention relates to a method and means for making a magnetic head, and particularly to a method and means of making a head of high resistivity material such as ferrite.

It is an object of the invention to provide a method of making a magnetic head having an extremely fine gap, superior high frequency performance and superior wear resistance.

Another object of the invention is to provide a magnetic head having a gap structure of high resistivity material providing a greatly improved gap dimension stability and precision.

A further object of the invention is to provide a novel magnetic head construction and method of making the same.

Still another object of the invention is to provide a novel method for making a magnetic head particularly adapted for use with ferrite or other high resistivity materials.

A still further object of the invention is to provide a novel magnetic head construction having a very precise stable gap structure capable of maintaining precise gap dimensions in spite of wear from the record medium thereon and the like.

Another and further object of the invention resides in the provision of an economical method for producing heads in quantity yet with a very high degree of precision.

Yet another object of the invention resides in the provision of a method of making a magnetic head which accommodates a more precise and less critical assembly procedure than is possible where individual poles of a magnetic head are individually formed.

An important advantage of the present invention resides in the fact that the gap faces are formed to optical flatness while part of a substantially more extended surface area. Very precise optical methods of polishing are available for such extended surfaces which could not be applied to individual gap defining faces of individual poles. The gap material is more readily applied to the more extended surfaces provided by the method of the present invention, and a much more precise gap is formed.

It is a further object of the present invention to provide a method of making a magnetic head wherein the gap is disposed in a very precise straight line.

It is a still further object of the present invention to provide a method for making a magnetic head wherein the gap space is very small and accurate.

Other objects, features and advantages of the present invention will be apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a perspective view of a different embodiment of the invention and illustrating a pair of blocks of magnetic material having confronting surfaces polished to optical flatness;

FIGURE 2 illustrates the confronting surfaces secured together at their flat surfaces;

FIGURE 3 is a diagrammatic perspective view illustrating the manner in which the assembly of FIGURE 2 is subdivided to provide a plurality of gap subassemblies;

FIGURE 4 is a diagrammatic perspective view of one of the gap subassemblies subdivided as indicated in FIGURE 3;



FIGURES 5, 6 and 7 illustrate steps in the finishing of the gap subassembly of FIGURE 4 into a magnetic transducer head pole assembly;

FIGURE 8 illustrates a yoke for receiving the gap assembly of FIGURE 7;

FIGURE 9 illustrates the final assembly of the subunits of FIGURES 7 and 8; and

FIGURES 10, 11 and 12 show further embodiments utilizing ferrite cores and vacuum deposited gap spacers.

As shown in the drawings:

The embodiment of FIGURES 1 to 9 of the present invention is particularly adapted for the forming of magnetic head assemblies from ferrite or high resistivity material, but can also be used for laminated structures and for applications where thick sections of magnetic material do not have excessive eddy current loss.

In accordance with the illustrated embodiment, a pair of ferrite blocks **210** and **211** have surfaces **210***a* and **211***a* thereof polished to optical flatness. By way of example, each block may be one-half inch square by one-quarter inch high (in the direction of arrow **216**). For quantity production a much larger area is practical. Single crystal ferrite is ideal to avoid the irregularities and granular structure of sintered ferrite, and preferably as indicated in FIGURE 1 the directions of easy magnetization of the single crystal ferrite blocks are those indicated by the arrows **213**, **214**, **215** and **216**. This orientation is preferred since it is in conformity with the direction of flux paths in the gap subassemblies to be formed from the blocks. With single crystal ferrite material it has been found that much finer gaps can be produced and maintained than are possible with sintered ferrites used in the prior art. However, the same construction is also applicable for less critical work, where fine grain ferrites may be used.

Homogeneous ferrite material which is not single crystal, or which is of imperfect crystal structure but has the required magnetic qualities (noted below) may be substituted for single crystal material. A preferred gap size is below 5 microns (one micron equals one millionth of a meter), and with care, assemblies with gaps of 0.25 microns or less may be formed.

In assembling the blocks as illustrated in FIGURE 2, a gap spacer **220** may be provided by depositing an evaporated film, for example gold in ¼ micron thickness, on one or both of the polished surfaces **210***a* and **211***a*. Alternatively a layer of foil of proper thickness may be used as a gap spacer, and for even finer gaps the spacer may be omitted entirely.

The mating surfaces **210***a* and **211***a* are then coated with epoxy resin of thin consistency and clamped together until the resin has hardened. Alternatively a low melting point "glass" may be used as an adhesive for the mating surfaces. Metals such as indium which wet and adhere to ferrite may also be used. For the very smallest gaps, cement need not be used on the gap faces.

FIGURE 2 illustrates the manner in which the block of FIGURE 2 may be cut along horizontal and vertical planes such as indicated at **223**, **224**, **225** and **226** to form gap units such as indicated at **230** in FIGURE 4 having gap sections **231** separating ferrite portions such indicated at **233** and **234**. In cases where cementing at the gap is not used reinforcing is applied to at least one side of each gap unit, for example as shown at **237'** in FIGURE 3, before the cuts are made.

After the step of FIGURES 3 and 4, a reinforcing piece **237** is fastened to one side of the unit **230** so as to allow the removal of material from the other side to reduce the gap facing area as indicated at **240** in FIGURE 6.

As shown in FIGURE 7, non-magnetic reinforcing material as indicated at **242** is fastened in the notch **240**

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illustrated in FIGURE 6, while tape receiving surfaces 244 and 245 are shaped, and surfaces such as indicated at 246 and 247 are made flat and coplanar.

As indicated in FIGURE 8, a yoke 250 is formed of ferrite material, with surfaces 250*a* and 250*b* polished flat and in the same plane to receive surfaces 246 and 247 of the gap unit shown in FIGURE 7. By way of example, the yoke 250 may be formed of single crystal ferrite with the directions of easy magnetization as indicated by the arrows 252 and 253 to conform with the flux path in the yoke. However it is preferable to make the yoke of sintered ferrite, which may be "molded" into the correct shape, and which is formed of a composition having superior magnetic properties including high initial permeability, high saturation flux density, and a high enough Curie point to insure stability at normal operating temperatures.

FIGURE 9 illustrates the final assembly with coils 256 and 257 and non-magnetic side plates 258 and 259 applied to the assembly of yoke 250 and gap subassembly 261 of FIGURE 7. The side plates facilitate mounting of the assembly and serve to strengthen and reinforce the gap unit in its mounting with the yoke 250. In many cases, the side plates 258 and 259 may be omitted and surfaces 246 and 247 and 250*a* and 250*b* glued in place.

FIGURE 10 illustrates a further ferrite head configuration indicated generally by the reference numeral 300. The head 300 may comprise two core parts 301 and 302 of a suitable ferrite material such as "Ferroxcube," this material comprising a manganese-zinc-ferrite composition. The part 301 may comprise a relatively straight bar of rectangular cross-section having edge portions defining planar gap faces 301*a* and 101*b*. The other part 302 is of a generally C-shape and has planar gap defining edge faces 302*a* and 302*b* confronting the faces 301*a* and 301*b*. The core part 302 may have a winding 304 wound thereon prior to assembly of the core part 302 with the core part 301. The edge gap defining face 301*a*, 301*b* and 302*a* and 302*b* may have a suitable non-magnetic gap material vacuum deposited thereon to a thickness of one micron, for example. Examples of suitable gap materials are aluminum, gold, chromium, titanium and silicon. The reference numerals 306, 307, 308 and 309 indicate diagrammatically gap material vacuum deposited on the respective gap faces 301*a*, 302*a*, 301*b*, 302*b*, and having a total thickness between the confronting gap faces which is preferably below 5 microns. When the core parts 301 and 302 are assembled with their respective gap layers in contact, the gap layers 306, 307 and 308, 309 completely fill the gaps in the magnetic circuit defined by the core parts 301 and 302. The head 300 may cooperate with a magnetizable record medium 312 which travels successively across the top edges of the core parts 301 and 302 in coupling relation to the non-magnetic gap defined by the gap layers 306 and 307. The assembly of FIGURE 10 may be secured in assembled relation by any suitable means, for example by potting the assembly in epoxy resin as indicated diagrammatically by the dash line 315.

FIGURE 11 shows an embodiment which is entirely similar to the embodiment of FIGURE 10, except that a second C-shaped ferrite core part 320 is substituted for the core part 301 in FIGURE 10 and carries a second coil 321. Corresponding primed reference numerals are given to similar parts. The end faces 320*a* and 320*b* are provided with vacuum deposited layers as indicated diagrammatically at 323 and 324 which together with the layers 307' and 309' of non-magnetic material completely fill the gaps in the magnetic circuit defined by the core parts 302' and 320. The total gap length of each gap in the magnetic circuit is preferably less than 5 microns and may, for example, be 2 microns. The gap spacer may be of any of the materials mentioned in connection with FIGURE 10.

FIGURE 12 illustrates a magnetic transducer head 340



comprising a pair of C-shaped core parts of ferrite material defining a ring-type head. In this embodiment, the end faces 341*a* and 342*a* are relatively spaced, while faces 341*b* and 342*b* may be in direct contact. In FIGURE 12, the upper gap is formed by thin pieces of metal magnetic material such as Mumetal pieces 344 and 345, so that the gap remains sharp even though the adjacent ferrite material of core parts 341 and 342 is somewhat irregular. The gap between the Mumetal parts 344 and 345 may be provided by vacuum depositing a suitable non magnetic material such as discussed above on one or both of the confronting surfaces 344*a* and 345*a* of the pole piece members 344 and 345. In FIGURE 12, the gap material 350 may be deposited on face 344*a* to completely fill the gap in the magnetic circuit including core parts 341 and 342 and pole piece members 344 and 345. The assembly of FIGURE 12 including windings 351 and 352 may be embedded in an epoxy resin casing as indicated by the dash line 355. It is found that the sandwich including pole piece parts 344 and 345 and gap material 350 should be kept very thin in the direction between faces 341*a* and 342*a* to avoid interference effects that produce a notch in the response curve at an audible frequency.

In each of the illustrated embodiments, the gap in the magnetic circuit is preferably less than 5 microns and is provided by metal deposited on one or more of the gap defining faces of the confronting magnetic parts. Vacuum deposition of the gap material is preferred for accuracy, although plating can be used. Copper is a desirable material for gap spacers because of its high conductivity and because a copper gap is readily observable under a microscope in contrast to the core pieces.

Facilities for evaporating metal are common in the optical industry for coating lenses and mirrors. Evaporated metal on plastic is also widely used for decorative emblems.

The present application is a continuation-in-part of Serial No. 723,304 filed March 24, 1958.

It will be apparent that many modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. A magnetic head comprising a pair of single crystal ferrite blocks having flat planar surfaces thereof in confronting relation to form a non-magnetic gap, said blocks having a direction of easy magnetization perpendicular to the plane of said confronting surfaces.

2. A magnetic head comprising a pair of homogeneous non-sintered ferrite members having respective surfaces in confronting relation to define a non-magnetic gap between said members.

3. A magnetic head comprising a pair of magnetic members of homogeneous ferrite material having respective surfaces in confronting relation to define a non-magnetic gap less than about 5 microns in length in the direction spanning said blocks.

4. A magnetic head comprising a pair of single crystal ferrite members having respective surfaces in confronting relation to define a non-magnetic gap.

5. A magnetic head comprising a pair of single crystal ferrite members having flat planar surfaces in confronting relation to form a non-magnetic gap for coupling to a magnetic record medium, and a yoke structure of sintered ferrite material forming a loop magnetic circuit with said single crystal ferrite members and the non-magnetic gap therebetween.

6. A magnetic head comprising a pair of single crystal ferrite members having flat planar surfaces in confronting relation and having an evaporated film of non-magnetic material deposited on at least one of said surfaces and rigidly determining the spacing between said surfaces to define a non-magnetic gap for coupling to a magnetic record medium.

7. A magnetic head comprising a pair of homogeneous

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non-sintered ferrite members having respective surfaces in confronting relation to define a non-magnetic gap for coupling to a magnetic record medium, and a yoke structure of sintered ferrite material forming a loop magnetic circuit with said homogeneous non-sintered ferrite members and the gap therebetween.

8. A magnetic head comprising a pair of single crystal ferrite members having respective surfaces in confronting relation to provide a region for coupling of the members to a magnetic record medium, a yoke structure of sintered ferrite material included in a loop magnetic circuit with said single crystal ferrite members, means defining a path of travel of a record member successively across said single crystal ferrite members and in coupling relation to said region provided by said surfaces, and a magnetoelectric transducing element coupled to said loop magnetic circuit.

9. A magnetic head comprising a pair of homogeneous non-sintered ferrite members having respective surfaces in confronting relation to define a non-magnetic gap between said members and having side surfaces disposed at right angles to said confronting surfaces, and unitary side plate means of non-magnetic material in contact with said side surfaces of the respective ferrite members and spanning the gap therebetween.

10. A magnetic head comprising a pair of homogeneous non-sintered ferrite members having respective surfaces in confronting relation to define a non-magnetic gap between said members, a yoke structure forming a loop magnetic circuit with said ferrite members and the gap therebetween, and side plate means of non-magnetic material laterally contacting a side surface of each of the ferrite members and of the yoke structure and spanning the gap between the ferrite members.

11. A magnetic head comprising a pair of homogeneous non-sintered ferrite members having respective surfaces in confronting relation and having an evaporated film



of non-magnetic material deposited upon at least one of said surfaces to rigidly determine the spacing therebetween and to define a non-magnetic gap for coupling to a magnetic record medium.

12. A magnetic head comprising a pair of single crystal ferrite members having respective surfaces in confronting relation and having an evaporated film deposited on at least one of said surfaces of approximately one-quarter micron thickness to rigidly determine the spacing between said members and to define a non-magnetic gap for coupling to a magnetic record medium.


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PAPER NO. 3

U. S. DEPARTMENT OF COMMERCE
PATENT OFFICE
WASHINGTON

IN REPLY PLEASE REFER TO: Group 3[illegible]

Frank R. Trifari
North American Philips Co., Inc.
Irvington-On-Hudson, N. Y.

Applicant: Hans Peter Peloschek
Ser. No. 277,829
Filed May 3, 1963
For METHOD OF MANUFACTURING PARTS OF ANNULAR MAGNETIC HEADS

MAILED
JUL 14 1964
GROUP 300

*Please find below a communication from the EXAMINER in charge of this application.*

*Commissioner of Patents.*

This application has been examined.

References made of record:

| | | | |
|---|---|---|---|
| Albers-Schoenberg | 2,728,054 | Dec. 20, 1955 | 336/178 |
| Cobb | 2,346,555 | Apr. 11, 1944 | 29/155.5B |
| Camaras | 3,079,470 (Filed Mar. 24, 1958) | Feb. 26, 1963 | 179/100.2C |
| Duinker | 3,094,772 | June 25, 1963 | 29/155.59 |
| Duinker | 3,117,367 | Jan. 14, 1964 | 29/155.5B |

The Draftsman has objected to the drawings as being informal because lines pale and blurred in parts, shade lines required, and Figure 8 must be transferred to sheet No. 1. Correction can be made and is required.

Claims 1-6 are rejected as being incomplete and indefinite thus failing to comply with 35 U.S.C. 112. The claims are obviously improper, alternative or improper product by process. New claims in proper form are required.

Claims 1-6 are rejected as not being patentable over the claimed subject matter of Duinker '772 or '367 or over the claimed subject matter of Applications

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278,012, 277,612, 175,536, 114,273, or 127,715. All assigned to the instant assignee. Each of the above patents and applications claims the method of assembling ferrite head parts with glass or enamel by fusion. No patentable distinction if found between this application and above plurality of patents and applications.

Claims 1-6 are rejected as not being patentable over Camaras '470 which teaches joining ground ferrite head parts by means of a fusible glass spacer and splitting the block into plural units.

Albers-Schoenberg and Cobb are made of record for teaching of fusion bonding magnetic elements.

lmb

J.W. Bock:lmb
WO 7-3753

J. F. Campbell
Examiner

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Nordwestdeutscher Rundfunk - Technische Hausmitteilungen

5th Year - 1953

# DEVELOPMENT REPORT OF FERRITE MAGNETIC TAPE RECORDER HEADS

by Rolf Cruel, Hamburg
Zentraltechnik

**SUMMARY:**

The heads used up to now, which are made of laminated, high-permeability iron, have only a short life owing to wear of the gap surfaces. Moreover, a comparatively high electrical output is needed for the erasing heads. The development of new heads of ferrite materials has shown that, at a tape speed of 76.2 cm/s, these heads are equal magnetically and in durability to the existing heads and are far superior to the latter in respect to electrical losses. The output required for an erasing head is less than 200 mW, which makes it possible to design light-weight, battery-supplied recording sets with high-frequency erasing.

The Sound Carrier Laboratory of the Northwest German Radio Corporation has carried on tests for more than a year to determine to what an extent ferrite materials, which are being used more and more for high frequency equipment, can be used for magnetic sound recording purposes.

These tests were caused by some properties of the Mu-metal heads in use at the present time, which were found disadvantageous in actual operation. It seemed possible that these disadvantages could be avoided by the use of ferrite metals. A certain part of the tests have come to some conclusion and therefore a report on the results obtained so far is in order. For this purpose it is advisable to give

some information regarding the construction and the properties of the Mu-metal sound recorder heads and to compare them against the ferrite heads.

Heads in Use at Present

The magnetic tape recorder heads in use at present in the radio industry consists of finely laminated sheets of high-permeability alloys (Mu-metal, Permalloy, Hyperm, etc.). The sheets have a thickness of 0.2 mm and are divided by lacquer coats in order to avoid larger eddy current losses. They are stacked to a height of 7 mm and fastened together with rivets (see Figure 1).

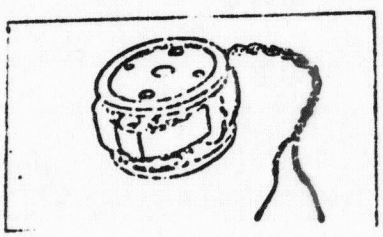

Fig. 1 Construction of laminated mu-metal heads.

These heads have shown very favorable properties for the present position of the tape recording art. They satisfy in general the quality requirements regarding erasure, recording and reproduction, because at the present time the quality and dynamic is limited by the quality of the tapes in use. In practical operation, however, certain disadvantages become apparent: On account of the grinding down of the relatively soft high-permeability alloys by the hard magnetite layer of the tapes, the heads progressively change their properties -

not to mention their short operating life. This is particularly noticeable in the reproducing and recording heads, because, in order to obtain high sensitivity, a very small gap depth must be used (about 0.3 mm), so that the change expressed in percentage becomes large in a relatively short operating time.

The reproducing heads show an increase of sensitivity and deterioration of the frequency transit. For the recording heads this represents a displacement of the working point of the premagnetisation towards smaller currents, an increase of sensitivity and an increase of the recording amplification. Even if we disregard the fact that these heads have to be discarded after only about 500 operating hours on account of the grinding off of the gap surfaces, still the continuous changes of the properties of the head put a considerable burden on the operators in charge of the studio and sender reproducing. After the installation of new heads a new adjustment of the amplifiers V 66/V 67 becomes necessary at least every four weeks in order to keep the frequency and the sensitivity within the required tolerances and to assure an even quality of the record and the reproduction. With continued operation this time shrinks to about a week until the heads finally must be withdrawn because adjustments become necessary too frequently.

The grinding down of the gap surfaces is of no great importance in erasure heads, because at first this even improves the erasure effect. However, even these heads are not satisfactory, because even at the relatively low erasure

frequency of 40 kHz they require a loss energy of about 3 watts on account of the eddy current losses, which causes considerable heating up of the erasure head. A relatively strong erasure generator tube has to be used (EDD 11 in V 66). That is the reason why until now it was impossible to use HF erasure in portable battery sound recording devices and it was necessary to use tapes which had previously been erased. Particularly in foreign countries and in territories where erasure equipment was not readily available this fact made it necessary either to carry along a large supply of tapes, adding to the burden of the reporter, or to restrict the recording time.

Ferrites

The ferrites have properties which make it appear likely that the disadvantages of the finely laminated recorder heads can be overcome. We do not have the space here to discuss the crystallographic constitution of the ferrites and the resulting properties in detail, we can only refer to the available literature (1) (2) (3). It may be mentioned, however, that ferrites consist of cubic mixed crystals of meO, $Fe_2O_3$ in which the double valent metal oxide consists of manganese oxide, nickel oxide, zinc oxide or a mixture of these oxides, depending upon the properties desired. Depending upon the composition of the raw material which, in form of a fine powder, is pressed under high pressure and then sintered at a temperature from 1000 to 1200°C, different ferrites are produced of which

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two suitable for tape recording devices are listed in Table 1.

Tab. 1

Schedule of the Ferromagnetic materials used

| | $\mu_A$ | $\mu_{max}$ | $B_s$(20° C) | $B_s$(100° C) | $H_c$(100° C) | $H_c$(20° C) | $\varrho$ | $\sigma$ |
|---|---|---|---|---|---|---|---|---|
| | | | T | T | Oe | Oe | Ω cm | g/cm³ |
| Ferroxcube III A | ~ 1 600 | ~ 2 500 | 3 000 | 1 000 | 0,05 | 0,1 | $>2 \cdot 10^1$ | 4,7 - 5,1 |
| Ferroxcube III B | ~ 1 100 | ~ 2 000 | 3 400 | 2 300 | 0,05 | 0,1 | $>2 \cdot 10^1$ | 4,7 - 5,1 |
| Mu-Metall | 15000 - 20000 | ~ 50000 - 80000 | 8 000 | 7 500 | 0,03 | 0,03 | $4,2 \cdot 10^{-5}$ | 8,6 |
| Hyperm | 500 | 6 000 | 18 000 | 17 000 | 0,3 | 0,5 | $1 \cdot 10^{-5}$ | 8,6 |

Only these two kinds come under consideration because they have the best permeability values which can be obtained with ferrites without allowing the Curie temperature to drop below 100°C. For the practical use of these two ferrite kinds it is furthermore important that the material have a specific density as high as possible, or with other words, the unavoidable hollow spaces caused by the sintering process must be kept very small (1 to 3 µ). Table 1 shows the properties of the two ferrites and also those of Mu-metal and Hyperm. In order to judge the usefulness of the two kinds of ferrite FXCIIIA and FXCIIIB it may be mentioned that, on account of the high saturation and the low temperature dependence of the saturation, the material FXCIIIB is suitable for recording and erasure heads, in spite of the low permeability. However, for reproducing heads the material FXCIIIA will be selected, because for

reproducing heads high permeability is desired in order to allow the smallest possible gap width. In the following we shall compare the results obtained up to now with ferrite heads and those obtained with recorder heads previously in use.

a) Erasure Heads

The record on a tape is erased by exposing the tape to a high frequency field for a duration of several periods. It is done by running the tape over a wide gap of the erasure head and leaves the head in demagnetised condition, depending upon the erasure frequency used and the field in front of the gap. Previously used erasure heads of Hyperm have a gap width of 200μ. For a frequency of 40 kHz and a current of 150 mA this results in an erasure dampening of 60 to 75 db, depending upon the kind of tape, the layer tapes being erased better than the mass tapes. The erasure dampening is determined by the field lines before the gap, which is shown in Figure 2

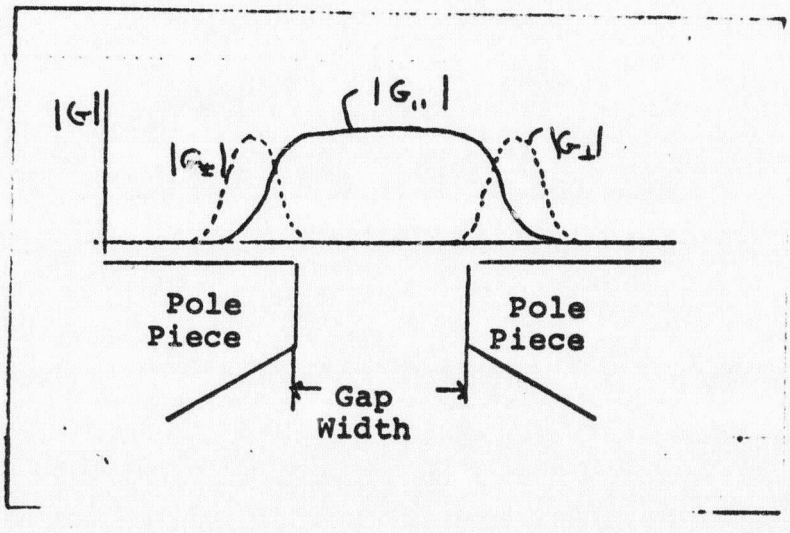


Fig. 2 Field in front of the gap of laminated erasure heads.

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for the previously used erasure heads. On account of the high permeability of Hyperm also for great field strengths, the transverse component of the field strength in the tape to be erased is large enough to produce also sufficient erasure dampening of the recorded transverse magnetisation on the tape.

The conditions are different for ferrite erasure heads. For this material the saturation field strength is about 1/4 of that of Hyperm and the permeability drops considerably for high field strengths and rising temperatures (see Table 1). This means when using material FXCIIIB a small transverse component before the gap of the erasure head, whereas the longitudinal component is relatively large and acts upon the tape for a long period of time. This has the result that ferrite erasure heads will not produce sufficient erasure of the transverse component of the record on the tape, if these ferrite heads are constructed in the same manner as previously used erasure heads of Hyperm. The measured results of these heads, therefore, were not satisfactory. In order to obtain sufficient erasure dampening with a ferrite head, it was necessary to increase the transverse component of the field strength in front of the gap or to increase the time of action on the tape. The latter was obtained by equipping the erasure head with a double gap, by installing a ferrite center bridge in a thickness of 1.5 mm between the two ferrite ring

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halves. At the same time the gap width was reduced to 50μ, because the action duration of the longitudinal component of the magnetic field in front of the gap is very large in the case of ferrites on account of the low saturation. The erasure dampening obtained with these center bridge ferrite erasure heads (Figure 3) is above 75 db for every kind of tape, with an erasure

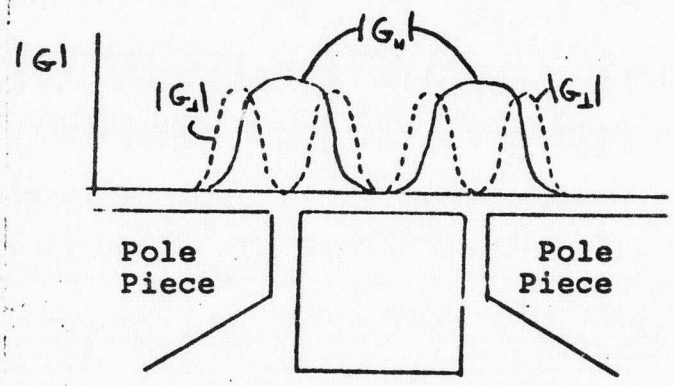


Fig. 3 Field in front of the gap of a double gap ferrite erasure heads.

frequency of 40 kHz and an erasure current of 150 mA, and it produces practically equal results for mass and for layer tapes.

If one considers not only the obtainable erasure dampening but also the necessary electric energy, the ferrite erasure head shows a noticeably more favorable picture. The former erasure heads, for the erasure frequency of 40 kHz used in the V 66, and for a current of 150 mA, require an electric energy of ∿3 watts. However, for the same erasure frequency and current, the double gap ferrite erasure head requires electric energy of <200 mW, and even a current of 100 mA

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produces an erasure dampening of >65 db, i.e., electric energy of 100 mW suffices to produce sufficient erasure dampening. These results made it possible to equip the portable sound recorder R 85 developed in the Sound Carrier Laboratory of the Northwest German Radio Corporation with an erasure head for a tape speed of 19.05 cm per second, without increasing noticeably the battery load. A DCC 90 in off-beat connection to avoid even harmonics is used in this equipment. For a frequency of 50 kHz and total anode current of 12 mA the premagnetisation current is 15 mA and the erasure current 100 mA. The erasure dampening for FS tape is >70 db. It is remarkable that the Mu-metal recording head used for this equipment requires a premagnetisation energy of ∿150 mW which is more than the ferrite erasure head requires, i.e., ∿100 mW. It is another advantage of the ferrite erasure head, that a considerably higher erasure frequency than 40 kHz can be used, without increasing noticeably the required electric energy. This results in better erasure and also in greater freedom from background noise in the record, because it avoids with certainty the recording of the erasure frequency on the tape and the inhomogenities of the tape cannot add to this background noise. (Erasure frequencies up to 300 kHz can be used without difficulty.)

b) <u>Recording Heads</u>

A comparison between recording heads of Mu-metal and those of ferrite metal is best done on the basis of requirements

of such a head for radio operation. It seems unnecessary to enter into details of the recording operation, as they have been covered in many publications (2). The requirements of a recording head for a tape speed of 76.2 cm per second are as follows:

1. The premagnetisation current necessary to obtain the standard working point for a frequency of 80 kHz must not be >19 mA.

2. The low frequency speaking current at 1000 Hz and full control of the tape must be <4 mA.

3. The required recording amplification at 10 kHz against 1 kHz must be $\leq$ 10 db.

4. The modulation noise recorded on the tape on account of the inhomogenities of the gape shall have the lowest possible value.

5. The changes of the head properties due to increasing grinding off, must be below the limits stated in paragraphs 1 to 3.

As shown in Table 2 these requirements are met by

Tab. 2

Quality factors of different magnetic recorder heads.

| | L (1 kHz) | L (10 kHz) | Q (1 kHz) | Q (10 kHz) | Q (40 kHz) | Q (80 kHz) | $2J_{opt}$ (80 kHz) | J (1 kHz) | J (10 kHz) / J (1 kHz) | Lösch-dämpf. | Modul.-Rausch.*) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | mH | mH | | | | | mA | mA | db | db | db |
| Ferrithörkopf | 75 | 75 | 20–25 | 40–50 | -- | — | -- | — | — | -- | — |
| Mu-Hörkopf | 70 | 49 | 10 | 3 | — | — | -- | — | — | -- | — |
| Ferritsprechkopf | 7,0 | 7,0 | 10–20 | 15–20 | 30–40 | 30–40 | 8–12 | 2,3–3,4 | 4–6 | — | 37 |
| Mu-Sprechkopf | 7,3 | 6,5 | 5,2 | 5,6 | ~2 | <2 | 13–16 | 3,0–4,5 | 5–7 | -- | 32 |
| Ferritlöschkopf | 1,4 | — | -- | — | 65–75 | 65–75 | — | — | — | 80–82 | -- |
| Mu-Löschkopf | 2,0 | -- | — | — | <1,6 | <1,6 | -- | — | — | 70–75 | — |

*) Gemessen mit Normalband P 498 und J (Gleichstrom) = 4 mA

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Mu-metal as well as by the ferrite recording head, although when the V 66 and a ferrite eraser head are connected together, on account of the faulty adaptation to the oscillator stage of the V 66, the required premagnetising current for the ferrite recording head can be obtained only by an additional dampening of the oscillator stage (connecting a resistance parallel to the eraser head). The table shows that in regard to pre-magnetising current and modulation noise the ferrite recording head shows more favorable values than the Mu-metal head. Furthermore, it should be noted that the construction of the two heads is alike, for all practical purposes, but that as rear air gap in ferrite recording heads a space of 1 mm produces reduced modulation noise, which compares to 4 mm for the Mu-metal recording heads. Figure 4 shows the required recording currents

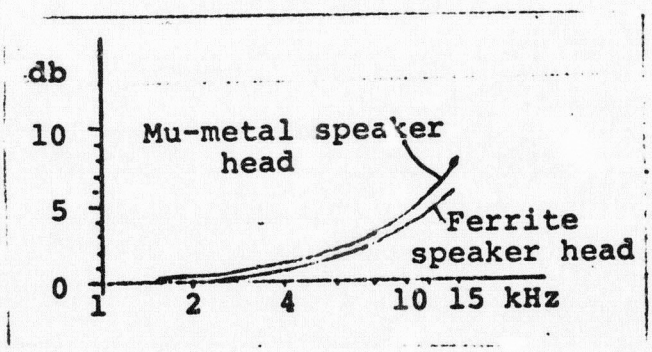


Fig. 4 Required speaker amplification for recording heads at a tape speed of 76.2 cm per second.

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for Mu-metal and ferrite recording heads in relation to the frequency, for a tape speed of 76.2 cm per second. The two curves are average values from a number of measurements. The curves show that the recording amplification is less than in the case of Mu-metal heads.

However, this is correct only for a tape speed of 76.2 cm per second. At a tape speed of 38 cm per second the required recording amplification is more favorable in the case of Mu-metal recording heads, for higher frequencies, at least at the present time. This is due to the following: The required recording amplification in order to obtain a certain magnetisation on the tape in relation to the frequency, is determined by the field distribution in front of the gap, on account of the increase of demagnetisation towards the shorter wave lengths. The size of this field is determined by two factors. The eddy current losses occurring in the head cause the effective gap field to become smaller as the frequency increases. As the eddy current losses in Mu-metal are several times the tenth power larger than in ferrites (see Table 2, quality factors), these frequency-depending field losses do not become apparent in the ferrite recording head. However, the wave length-dependent losses, which are determined by the width of the effective field in front of the gap, are smaller for Mu-metal heads than for ferrite heads,

because the considerably larger permeability of Mu-metal restricts the effective recording field to a smaller space. In the case of ferrite recording heads, a partial erasure of the record takes place, in the case of short recorded wave lengths, on account of the larger extent of the field, because the record has not yet left the effective field when the next half cycle reverses the field in front of the gap. The addition of these two causes for the necessary recording amplification necessitates overlapping of the recording curves for the Mu-metal and ferrite recording head for a tape speed of 38 cm per second, whereas for a tape speed of 76 cm per second the wave length-dependent losses of the ferrite head remain unnoticeable. On account of the wide field in the case of the ferrite recording there is no recording of the premagnetisation, which can be determined in the case of the Mu-metal recording head. In the case of the ferrite recording head it is naturally just as possible as in the case of the erasure head to increase the premagnetisation frequency to about 300 kHz, which avoids with certainty the formation of differential tones between the modulation and the premagnetisation frequency.

c) Reproducing Heads

The principal properties of a reproducing head are the sensitivity, which is a function of the gap depth and the rear magnetic circuit, as well as the losses.

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1. Electric Losses

In this case the ferrite heads are superior to the Mu-metal reproducing heads, as shown in Figure 5, because the

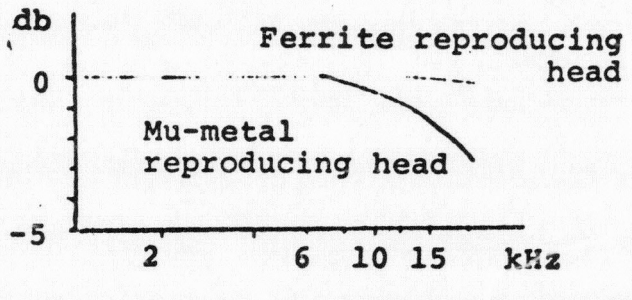


Fig. 5 Electric losses of the reproducing heads.

eddy current losses in ferrites in the usual frequency range is far below 0.1 db, whereas in the case of Mu-metal reproducing heads these losses cannot be disregarded.

2. Gap Losses

The gap losses of a reproducing head can closely be represented by the gap equation.

$$f(\lambda) = \frac{\sin \pi d/\lambda}{\pi d/\lambda}$$

if the first zero position is assumed to be the effective gap width. This effective gap width, in Mu-metal heads, equals approximately the mechanical gap width (14μ).
In ferrite reproducing heads for which the FXCIIIA metal has been used, with a starting permeability of 1600 against 12,000 - 17,000 for Mu-metal, results generally a higher effective gap width than the mechanical gap width. The measured effective gap width depends to a great extent upon

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the mechanical finish of the gap edges. In addition to the increase of the effective gap width caused by the air enclosures, the grinding of the polished surface of the head causes on the gap edges easily a rounding off, when the foil is too soft and the ferrites break out. It is therefore important to find a suitable foil material, which should have about the same hardness as the ferrites. The bronze foil heretofore used for this purpose, does not answer these requirements. In spite of that, the results obtained to date are practically equal to those of Mu-metal heads regarding the resolution of the short wave lengths on the tape above 50µ (Figure 6). A considerable improvement of the resolution can be expected if, after the mechanical finishing of the ring

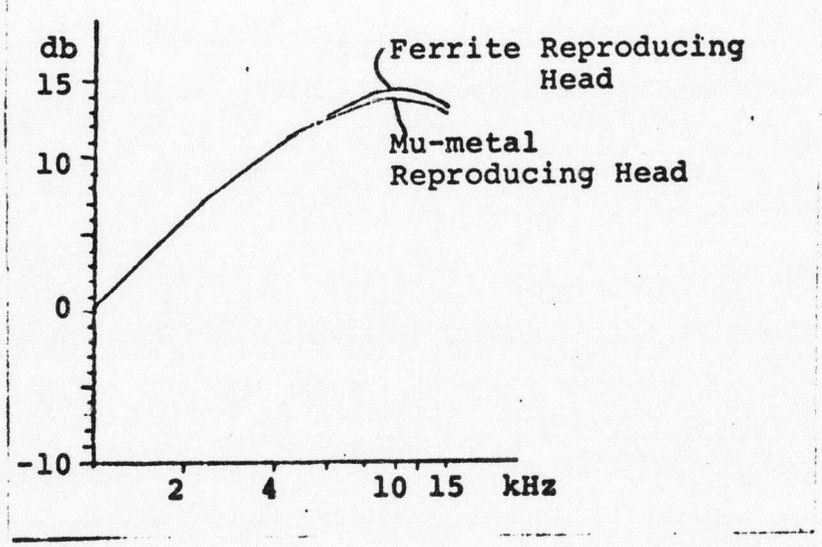


Fig. 6 EMK curves of the reproducing heads at 76.2 cm per second tape speed.

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halves has been done, the gap surfaces are glazed in foil thickness. The experiments being made in this respect have not yet been brought to a conclusion. However, it may be assumed with certainty, that thereafter ferrite reproducing heads will have an EMK curve for tape speeds of 38 cm per second practically equal to that of Mu-metal heads, in which case a somewhat smaller mechanical gap width is required. However, it appears improbable, on the basis of present findings, that satisfactory results can be obtained with ferrite reproducing heads for tape speeds of 19.05 cm per second and lower.

3. Losses independent from the frequency

To the above losses must be added those which do not depend upon the frequency and which are determined by the limited size of the magnetic resistance in the front gap. This gap is a bypass for the flow entering into the head from the tape. For Mu-metal reproducing heads it amounts to about 30% of the useful flow for medium wave lengths, and for ferrite heads it can be brought to at least the same value, in spite of the larger magnetic resistance of the ring, by a reduction of the gap depth. This can be done in ferrite reproducing heads without noticeable disadvantages, because the hardness of the material prevents changes of the head properties for a great length of time. This produces for all practical purposes the same sensitivity as in the new reproducing heads of the A.E.G.

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Figure 7 shows the loss resistances of Mu-metal and

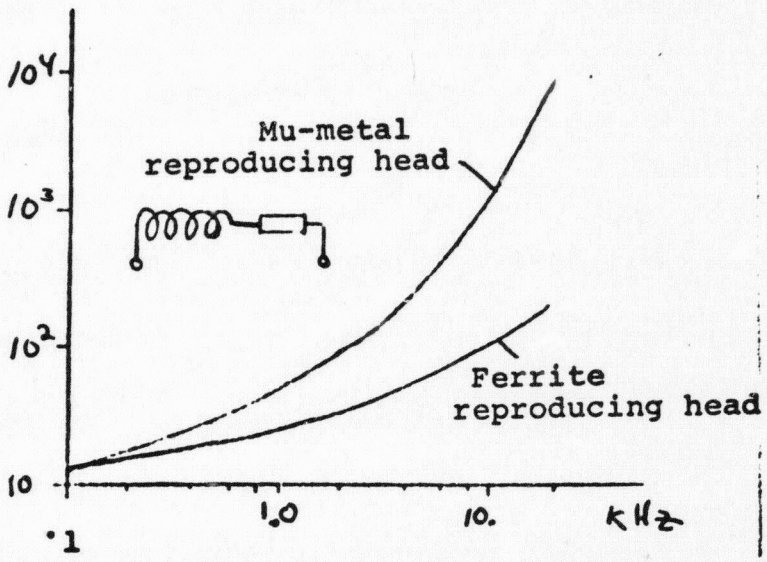


Fig. 7 Series loss resistance of the reproducing heads.

ferrite reproducing heads in relation to the frequency. The size of the loss resistances determines the resistance noise of the head in the frequency range under consideration. The figure shows that the ferrite reproducing head is considerably more favorable, although this could not be measured when connected with the reproduction amplifier V 67, because the noise of the entrance tube EF 40 throughout the entire frequency range exceeds the head noise. For special purposes, i.e., for high tape speeds (about 2 m per second) and a frequency range to about 100 kHz the head noise probably cannot be neglected, regardless of the fact that for these frequencies the ferrite reproducing head would show better results in regard to its EMK, on account of the considerable electric losses in this case.

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d) Operating Experience with Ferrite Heads

In the medium wave sender of the Northwest German Radio Corporation in Hamburg a head carrier with ferrite heads has been used during the last year. At the same time a Mu-metal carrier was equipped with new heads in a second position. The Mu-metal heads had to be removed from service after only about 500 operating hours on account of grinding through of the gap surfaces, whereas at the ferrite head carrier it was unnecessary to adjust the amplifiers throughout the whole time and it was impossible to measure any grinding off at any of the heads, although intentionally also the rewinding of the tape was done without lifting it from the heads. It is very probable that the life of the ferrite heads will be at least ten times as long as that of the Mu-metal heads. At present four recorder microphones in the Northwest German Radio Corporation, Hamburg, are equipped with ferrite head carriers, in order to test their time constancy on a larger scale. Very shortly also other senders of the Northwest German Radio Corporation will be supplied with head carriers with ferrite heads. Difficulties with ferrite heads during operation have been experienced on the one hand by static charges on mass tapes, caused by the high specific resistance of the ferrites. Good grounding of the ring halves immediately adjacent to the polished surfaces suppressed this trouble entirely. In order to reduce the electric losses in the heads, the Sound Carrier Laboratory

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developed a "Trolitul Mount" which assured optimum quality and easy mounting of all three kinds of heads. The manufacture of heads from ferrite requires extreme precision of the polishing equipment, if satisfactory results are to be obtained. On account of the great hardness of the material the manufacture is not quite simple even then, and about 50% throw-outs must be expected. The manufacturing costs consist principally of labor, because the material costs are unimportant. It may be mentioned that ferrite heads must be protected against shock.

## SUMMARY

The development of ferrite heads in the Sound Carrier Laboratory of the Northwest German Radio Corporation has now reached a stage which, in our opinion, makes it possible to introduce them into the radio industry for tape speeds of 76.2 cm per second. There is no doubt that the double gap erasure heads represent considerable progress in their properties. The ferrite speaker heads are at least equal to previously known recording heads and represent an improvement of the modulation noise of >5 db. By increase of the premagnetisation frequency the differential tones can, no doubt, be entirely suppressed. Ferrite reproducing heads are, as regards their EMK properties, at 76.2 cm per second, almost equal to the previously known Mu-metal heads (Ellipsen Heads), and in connection with the reproduction amplifier

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V 67 a dissolution to 15 kHz can be obtained, while also, on account of the constant electric properties of the ferrite reproducing head (self induction independent from the frequency), a change of the counter-coupling makes further improvement possible. We should emphasize the great time constancy and long life of the ferrite heads which far exceed those of previously known heads. The development of ferrite reproducing and recording heads is not yet concluded for a tape speed of 38.1 cm per second, but it appears that also this problem can be solved. The speaker head can already be used in its present form for this speed, provided the recording amplification is adjusted when changing from 76.2 cm per second to 38.1 cm per second tape speed, which is also planned for Mu-metal heads. For reproducing heads adjustment and dissolution is necessary, but the present ferrite reproducing heads furnish at the low speed a constant ledge value on the V 67 only up to 12 kHz. A report will be made as soon as the development of ferrite reproducing and recording heads for 38.1 cm per second tape speed has been concluded.

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Technische Hausmitteilungen 5, Nr. 3/4, März/April 1953, 60-63.

R6 R14

NWDF

Entwicklungsbericht über Ferritmagnettonköpfe

CALCUE AANWEZIG Lab. Gelsenkirchen 17/4'59

# ENTWICKLUNGSBERICHT ÜBER FERRITMAGNETTONKÖPFE

VON ROLF CRUEL, HAMBURG
ZENTRALTECHNIK

E

DK 621.396.625.3

**Zusammenfassung**

Die bis her gebrauchten Magnettonköpfe, die aus lamelliertem, hochpermeablem Eisen hergestellt sind, haben nur kurze Lebensdauer infolge des Abschliffes der Spaltflächen. Darüber hinaus ist eine relativ hohe elektrische Leistung für die Löschköpfe erforderlich. Die Entwicklung neuer Tonköpfe aus Ferritmaterial hat gezeigt, daß bei einer Bandgeschwindigkeit von 76,2 cm/sec diese Köpfe magnetisch und in ihrer Haltbarkeit den bestehenden Köpfen gleichwertig sind. Sie sind den letzteren weit überlegen in Bezug auf elektrische Verluste. Die erforderliche Leistung in einem Löschkopf liegt unter 200 mW, wodurch es möglich wird, leichte batteriegespeiste Magnetophone mit Hochfrequenzlöschung auszustatten.

**Summary**

The heads used up to now, which are made of laminated, high-permeability iron, have only a short life owing to wear of the gap surfaces. Moreover, a comparatively high electrical output is needed for the erasing heads. The development of new heads of ferrite materials has shown that, at a tape speed of 76.2 cm/s, these heads are equal magnetically and in durability to the existing heads and are far superior to the latter in respect to electrical losses. The output required for an erasing head is less than 200 mW, which makes it possible to design light-weight, battery-supplied recording sets with high-frequency erasing.

**Résumé**

Les têtes utilisées jusqu'ici et qui sont faites de lamelles de fer de haute perméabilité, ont une vie courte à cause de l'usure des surfaces d'entrefer. Une puissance électrique relativement élevée est, de plus, nécessaire pour les têtes d'effacement. L'emploi de têtes nouvelles, en ferrite, a montré que, pour une vitesse de bande de 76,2 cm/s, ces têtes sont comparables à celles qui sont actuellement utilisées, du point de vue de leurs caractéristiques magnétiques et de leur longévité, et qu'elles leur sont de loin supérieures en ce qui concerne les pertes électriques. La puissance nécessaire pour la tête d'effacement est inférieure à 200 mW, ce qui rend possible la construction d'appareils enregistreurs légers, alimentés par batterie et pourvus d'un dispositif d'effacement par haute fréquence.

Im Tonträgerlabor des Nordwestdeutschen Rundfunks werden seit über einem Jahr Versuche durchgeführt, um festzustellen, inwieweit die Ferritmaterialien, die in immer stärkerem Maße in der Hochfrequenztechnik Verwendung finden, auch auf dem Gebiet der magnetischen Schallaufzeichnung angewandt werden können.

Diese Versuche wurden angeregt durch einige Eigenschaften der zur Zeit im Rundfunk gebräuchlichen Mu-Metallköpfe, die sich im Betriebe als nachteilig herausgestellt haben. Bei der Verwendung von Ferriten erschien eine Vermeidung dieser Mängel möglich. Nachdem nun bei einem Teil der Untersuchungen ein gewisser Abschluß erzielt wurde, soll deshalb nachstehend ein Bericht über die bisher erzielten Resultate gegeben werden. Dazu ist es zweckmäßig, eine Übersicht über den Aufbau und die Eigenschaften der Mu-Metall-Magnettonköpfe zu geben und diesen die Eigenschaften der Ferritköpfe gegenüber zu stellen.

## Bisherige Köpfe

Die bisher im Rundfunk verwendeten Magnettonköpfe bestehen aus feinlamellierten Blechen hochpermeabler Legierungen (Mu-Metall, Permalloy, Hyperm usw.). Die Bleche haben eine Stärke von 0,2 mm und werden, zur Vermeidung größerer Wirbelstromverluste durch Lackschichten getrennt, zu einer Höhe von 7 mm aufeinander geschichtet und mittels Nietbolzen zusammengehalten (s. Abb. 1).

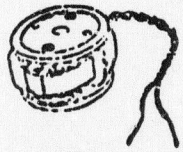

**Abb. 1**
Aufbau der lamellierten Mu-Metall-Köpfe

Diese Köpfe haben bei dem heutigen Stand der Magnettontechnik sehr günstige Eigenschaften erzielt. Sie genügen im allgemeinen den Qualitätsanforderungen, die bezüglich Löschung, Aufnahme und Wiedergabe gestellt werden, da zur Zeit die erzielbare Dynamik und Qualität durch die Eigenschaften der verwendeten Bänder begrenzt wird. Im Betriebe jedoch treten einige Nachteile in Erscheinung: Infolge des Abschliffs der verhältnismäßig weichen hochpermeablen Legierungen an der harten Magnetitschicht der Bänder entsteht — abgesehen von der kurzen Lebensdauer der Köpfe — eine fortschreitende Änderung ihrer Eigenschaften. Dies tritt vor allem bei den Hör- und Sprechköpfen auf, da hier zur Erzielung hoher Empfindlichkeit eine sehr geringe Spalttiefe gewählt werden muß (etwa 0,3 mm), so daß die prozentuale Änderung der Spalttiefe schon nach verhältnismäßig kurzer Betriebszeit groß wird.

Bei den Hörköpfen ergibt sich eine Zunahme der Empfindlichkeit und eine Verschlechterung des Frequenzganges. Für die Sprechköpfe bedeutet es eine Verlagerung des Arbeitspunktes der Vormagnetisierung zu kleineren Strömen hin, eine Zunahme der Empfindlichkeit und eine Vergrößerung der erforderlichen Aufsprechüberhöhung. Selbst wenn man von der Tatsache absieht, daß diese Köpfe bereits nach etwa 500 Betriebsstunden wegen Durchschliffs der Spaltflächen ausfallen, so bedeutet die laufende Veränderung der Kopfeigenschaften eine wesentliche Belastung des technischen Personals, das die Überwachung der Studio- und Sendemagnetofone durchführt. Bei neu eingesetzten Köpfen ist mindestens vierwöchentlich eine Neueinmessung der Verstärker V 66/V 67 erforderlich, um den Frequenzgang und

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die Empfindlichkeit innerhalb der zugelassenen Toleranzen zu halten, und damit eine gleichbleibende Qualität von Aufnahme und Wiedergabe zu gewährleisten. Mit zunehmender Betriebsdauer der Köpfe verkürzt sich diese Zeit auf etwa 8 Tage, bis die Köpfe schließlich wegen der immer schnelleren Veränderungen aus dem Betrieb gezogen werden müssen.

Der Abschliff bis zum Durchschliff der Spaltflächen spielt bei den Löschköpfen keine große Rolle, da hier sogar zunächst eine Verbesserung der Löschdämpfung eintritt. Trotzdem sind auch diese Köpfe nicht zufriedenstellend, da sie selbst bei der verhältnismäßig niedrigen Löschfrequenz von 40 kHz schon auf Grund der Wirbelstromverluste eine elektrische Verlustleistung von etwa 3 Watt benötigen die zu einer beträchtlichen Erwärmung des Löschkopfes führt. Eine verhältnismäßig starke Löschgeneratorröhre (FDD 11 im V 66) muß verwendet werden. Daher war es bisher auch nicht möglich, in tragbaren batteriegespeisten Magnettongeräten die HF-Löschung anzuwenden, so daß man stets auf vorgelöschte Bänder angewiesen war. Besonders im Ausland und in abgelegenen Gebieten, in denen keine Bandlöscheinrichtungen greifbar waren, führte dieses entweder zur Mitnahme eines großen Vorrates an Bändern und damit zu einer zusätzlichen Belastung des Reporters, oder aber zu einer Begrenzung der Aufnahmezeit.

## Ferrite

Die Ferrite haben Eigenschaften, die eine Beseitigung der Nachteile der feinlamellierten Magnettonköpfe möglich erscheinen lassen. Es würde zu weit führen, an dieser Stelle den kristallographischen Aufbau der Ferrite und die daraus resultierenden Eigenschaften im einzelnen zu besprechen, und es wird auf die vorhandene Literatur verwiesen [1] [2] [3]. Es sei jedoch erwähnt, daß die Ferrite aus kubischen Mischkristallen der Struktur $MeO,Fe_2O_3$ bestehen, bei denen je nach der gewünschten Eigenschaft das zweiwertige Metalloxyd aus Manganoxyd, Nickeloxyd, Zinkoxyd oder aus Gemischen dieser Oxyde besteht. In Abhängigkeit von der jeweiligen Zusammensetzung des Ausgangsproduktes, welches in fein verteilter Form unter hohem Druck gepreßt und dann bei einer Temperatur von 1000 bis 1200° C gesintert wird, ergeben sich die verschiedenen Ferrite, von denen zwei für das Magnettongebiet in Betracht kommende Sorten in der Tabelle 1 aufgeführt sind. Nur diese beiden Arten kommen in Frage, da sie die höchsten Permeabilitätswerte aufweisen, die bei Ferriten erzielt werden können, ohne die Curie-Temperatur unter 100° C absinken zu lassen. Für die Verwendbarkeit der beider in Betracht kommenden Ferritsorten ist weiterhin eine möglichst hohe spezifische Dichte des Materials wichtig, d. h. die durch den Sinterungsprozeß entstehenden unvermeidbaren Hohlräume müssen in ihren Abmessungen sehr klein sein (1 bis 3 $\mu$). In der Tabelle Nr. 1 sind nun die Eigenschaften der beiden Ferrite zusammen mit Mu-Metall und Hyperm aufgeführt. Zur Beurteilung der Verwendungsmöglichkeit der beiden Ferritarten FXC III A und FXC III B ist zu erwähnen, daß auf Grund der höheren Sättigung und der geringeren Temperaturabhängigkeit der Sättigung das Material FXC III B trotz der geringeren Permeabilität für Sprech- und Löschköpfe geeignet ist. Dagegen wird man für Hörköpfe das Material FXC III A wählen, da bei den Hörköpfen zur Erzielung einer möglichst geringen effektiven Spaltbreite eine hohe Permeabilität erwünscht ist. Im Folgenden sollen nun die mit Ferritköpfen bisher erzielten Ergebnisse mit den entsprechenden zur Zeit verwendeten Magnettonköpfen verglichen werden.

### a) Löschköpfe

Die Löschung einer Aufzeichnung auf einem Magnettonband erfolgt in der Weise, daß das Band einem hochfrequenten Wechselfeld über einen Zeitraum von mehreren Perioden ausgesetzt wird. Es geschieht in der Form, daß das Band über einen breiten Spalt des Löschkopfes läuft und dabei entsprechend der verwendeten Löschfrequenz und dem Feldverlauf vor dem Spalt ein abklingendes Wechselfeld und damit im entmagnetisierten Zustand den Löschkopf verläßt. Die Spaltbreite der bisherigen Löschköpfe aus Hyperm beträgt 200 $\mu$. Bei einer Frequenz von 40 kHz und einem Strom von 150 mA ergibt sich damit je nach Bandsorte eine Löschdämpfung von 60 bis 75 db, wobei die Schichtbänder besser gelöscht werden als die Massebänder. Bestimmend für die erzielte Löschdämpfung ist der Feldverlauf vor dem Spalt, der in Abb. 2 für die bisherigen Löschköpfe wiedergegeben ist. Auf Grund der hohen Permeabilität von Hyperm auch bei großen Feldstärken ist die Querkomponente der Feldstärke

Tab. 1
Übersicht über die verwendeten ferromagnetischen Stoffe

| | $\mu_A$ | $\mu_{max}$ | $B_s$(20° C) | $B_s$(100° C) | $H_c$(100° C) | $H_c$(20° C) | $\varrho$ | $\sigma$ |
|---|---|---|---|---|---|---|---|---|
| | | | Γ | Γ | Oe | Oe | Ω cm | g/cm³ |
| Ferroxcube III A | ~ 1 600 | ~ 2 500 | 3 000 | 1 000 | 0,05 | 0,1 | $\geq 2 \cdot 10^3$ | 4,7–5,1 |
| Ferroxcube III B | ~ 1 100 | ~ 2 000 | 3 400 | 2 300 | 0,05 | 0,1 | $\geq 2 \cdot 10^3$ | 4,7–5,1 |
| Mu-Metall | 15 000 – 20 000 | ~ 50 000 – 80 000 | 8 000 | 7 500 | 0,03 | 0,03 | $4,2 \cdot 10^{-5}$ | 8,6 |
| Hyperm | 500 | 6 000 | 13 000 | 17 000 | 0,3 | 0,5 | $1 \cdot 10^{-5}$ | 8,6 |

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in dem zu löschenden Bande groß genug, um eine genügende Löschdämpfung auch der aufgezeichneten Quermagnetisierung auf dem Band zu erzielen.

Bei den Ferritlöschköpfen liegen die Verhältnisse anders. Hier ist die Sättigungsfeldstärke etwa 1/3 der von Hyperm und die Permeabilität sinkt bei hohen Feld-

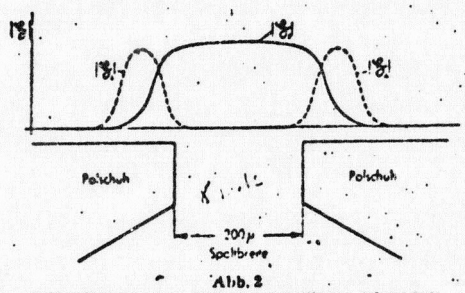


Abb. 2
Feldverlauf vor dem Spalt der lamellierten Löschköpfe

stärken und steigenden Temperaturen schon beträchtlich (s. Tabelle 1). Das aber bedeutet bei der Verwendung des Materials FXC III B eine kleine Querkomponente vor dem Spalt des Löschkopfes, während die Längskomponente verhältnismäßig groß ist und über einen langen Zeitraum auf das Band einwirkt. Die Folge davon ist, daß bei Ferritlöschköpfen mit dem gleichen Aufbau wie den bisherigen Löschköpfen aus Hyperm keine ausreichende Löschung der Querkomponente der Aufzeichnungen auf dem Band erzielt werden kann. Die mit diesen Köpfen gemessenen Ergebnisse waren deshalb nicht befriedigend. Um nun auch mit einem Ferritlöschkopf eine ausreichende Löschdämpfung zu erzielen, war es notwendig, die Querkomponente der Feldstärke vor dem Spalt zu vergrößern oder die Einwirkungszeit auf das Band zu verlängern. Das letztere wurde dadurch erreicht, daß der Löschkopf mit einem Doppelspalt versehen wurde, indem ein Ferrit-Mittelsteg in einer Stärke von 1,5 mm zwischen den beiden Ferrit-Ringhälften eingebaut wurde. Gleichzeitig damit wurde die Spaltbreite auf 50 µ reduziert, da die Einwirkungsdauer der Längskomponente des Magnetfeldes vor dem Spalt auf Grund der niedrigen Sättigung bei den Ferriten schon sehr groß ist. Die mit diesen Mittelsteg-Ferritlöschköpfen (Abb. 3) erzielte Löschdämpfung liegt bei jeder Bandsorte bei einer Löschfrequenz von 40 kHz und einem Löschstrom von 150 mA über 75 db

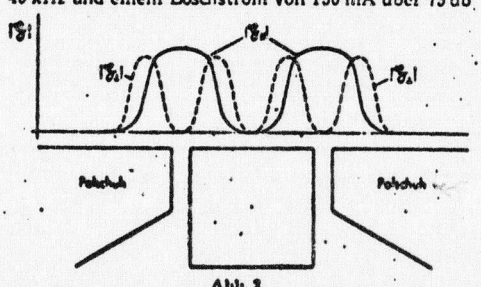


Abb. 3
Feldverlauf vor dem Spalt eines Ferrit-Doppelspalt-Löschkopfes

und ergibt praktisch gleiche Resultate sowohl bei Masse- als auch bei Schichtbändern.

Betrachtet man nun neben der erzielbaren Löschdämpfung auch die dazu notwendige elektrische Leistung, so ergibt sich für den Ferritlöschkopf ein noch wesentlich günstigeres Bild. Die bisherigen Löschköpfe benötigen bei der zur Zeit im V 65 verwendeten Löschfrequenz von 40 kHz bei einem Strom von 150 mA eine elektrische Leistung von ~ 3 Watt. Dagegen genügt bei gleicher Löschfrequenz und Stromaufnahme für den Doppelspalt-Ferritlöschkopf eine elektrische Leistung von < 200 mW, wobei schon ein Strom von 100 mA eine Löschdämpfung > 65 db gewährleistet, d. h. eine elektrische Leistung von 100 mW genügt zur Erzielung einer ausreichenden Löschdämpfung. Auf Grund dieser Ergebnisse wurde es möglich, das im Tonträgerlabor des NWDR entwickelte tragbare Magnettongerät R 65 für eine Bandgeschwindigkeit von 19,05 cm/s mit einem Löschkopf auszurüsten, ohne die Batteriebelastung wesentlich zu erhöhen. So wird in diesem Gerät eine DCC 90 in Gegentaktschaltung zur Vermeidung der geradzahligen Harmonischen benutzt. Bei einer Frequenz von 50 kHz und einem Gesamtanodenstrom von 12 mA beträgt der Vormagnetisierungsstrom 15 mA und der Löschstrom 100 mA. Die Löschdämpfung bei Verwendung von FS-Band ist > 70 db. Bemerkenswert ist dabei, daß der verwendete Mu-Metall-Sprechkopf dieses Gerätes eine Vormagnetisierungsleistung von ~ 150 mW erfordert und somit höher liegt als der Ferritlöschkopf mit ~ 100 mW. Ein weiterer Vorteil des Ferritlöschkopfes ist die Möglichkeit, daß man eine wesentlich höhere Löschfrequenz als 40 kHz verwenden kann, ohne daß die erforderliche elektrische Leistung wesentlich ansteigt. Dies aber gewährleistet neben einer besseren Löschung eine größere Rauschfreiheit der Aufnahme, da hierdurch mit Sicherheit eine Aufzeichnung der Löschfrequenz auf dem Band vermieden wird und die Inhomogenitäten des Bandes nicht zum Rauschen beitragen können. (Die Benutzung einer Löschfrequenz bis zu 300 kHz ist ohne weiteres möglich.)

### b) Sprechköpfe

Ein Vergleich zwischen den Sprechköpfen aus Mu-Metall und den Ferritsprechköpfen erfolgt am besten anhand der Anforderungen, die an einen Sprechkopf im Rundfunkbetrieb gestellt werden. Es erübrigt sich wohl, dabei auf die Einzelheiten des Aufsprechvorganges einzugehen, da diese bereits in zahlreichen Veröffentlichungen [2] dargestellt wurden. Die Anforderungen an einen Sprechkopf für eine Bandgeschwindigkeit von 76,2 cm/s sind durch folgende Daten festgelegt:

1. Der zur Erzielung des festgelegten Arbeitspunktes erforderliche Vormagnetisierungsstrom bei einer Frequenz von 80 kHz darf nicht > 19 mA sein.
2. Der niederfrequente Aufsprechstrom bei 1000 Hz und einer Vollaussteuerung des Bandes soll < 4 mA sein.
3. Die erforderliche Aufsprechüberhöhung bei 10 kHz gegenüber 1 kHz muß ≤ 10 db sein.
4. Das Modulationsgeräusch, das bei der Aufnahme infolge der Inhomogenitäten auf dem Bande auf-

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Tab. 2
Gütefaktoren der verschiedenen Magnettonköpfe

| | L (1 kHz) | L (10 kHz) | Q (1 kHz) | Q (10 kHz) | Q (40 kHz) | Q (80 kHz) | $2 J_{opt}$ (80 kHz) | J (1 kHz) | J (10 kHz) / J (1 kHz) | Löschdämpf. | Modul.–Rausch.*) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | mH | mH | | | | | mA | mA | db | db | db |
| Ferrithörkopf | 75 | 75 | 20–25 | 40–50 | -- | — | -- | — | — | -- | — |
| Mu-Hörkopf | 70 | 49 | 10 | 3 | — | — | -- | — | — | -- | — |
| Ferritsprechkopf | 7,0 | 7,0 | 10–20 | 15–20 | 30–40 | 30–40 | 8–12 | 2,3–3,4 | 4–6 | — | 37 |
| Mu-Sprechkopf | 7,3 | 6,5 | 5,2 | 5,6 | ~2 | < 2 | 13–16 | 3,0–4,5 | 5–7 | -- | 32 |
| Ferritlöschkopf | 1,4 | — | — | — | 65–75 | 65–75 | — | — | — | 80–82 | -- |
| Mu-Löschkopf | 2,0 | — | — | — | < 1,6 | < 1,6 | -- | — | — | 70–75 | — |

*) Gemessen mit Normalband P 498 und J (Gleichstrom) = 0 mA

gezeichnet wird, soll einen möglichst niedrigen Wert haben.

5. Die Änderung der Kopfeigenschaften mit zunehmendem Abschliff soll innerhalb der unter 1. bis 3. genannten Grenzen bleiben.

Wie in der Tabelle 2 gezeigt, werden diese Forderungen sowohl von dem Mu-Metall- als auch dem Ferrit-Sprechkopf erfüllt, wenn auch in Zusammenschaltung mit dem V 66 und einem Ferrit-Löschkopf infolge der Fehlanpassung an die Oszillatorstufe des V 66 der erforderliche Vormagnetisierungsstrom für den Ferritsprechkopf nur durch eine zusätzliche Bedämpfung der Schwingstufe (Parallelschaltung eines Widerstandes zum Löschkopf) erreicht werden kann. Es ist jedoch aus der Tabelle ersichtlich, daß bezüglich Vormagnetisierungsstrom und Modulationsgeräusch der Ferritsprechkopf günstigere Werte hat als der Mu-Metallsprechkopf. Hierzu ist noch zu bemerken, daß der Aufbau der Köpfe praktisch gleich ist, jedoch als hinterer Luftspalt bei den Ferritsprechköpfen ein Abstand von 1 mm gegenüber 4 mm bei den Mu-Metallköpfen schon ein geringeres Modulationsgeräusch ergibt. In der Abb. 4 sind die erforderlichen Aufsprechströme für Mu-Metall- und Ferritsprechköpfe in Abhängigkeit von der Frequenz für eine Bandgeschwindigkeit von 76,2 cm/s aufgezeichnet. Die beiden Kurven stellen Mittelwerte aus einer Anzahl von Kopfmessungen dar. Wie aus den Kurven ersichtlich, liegt die Aufsprechüberhöhung niedriger als bei den Mu-Metallköpfen.

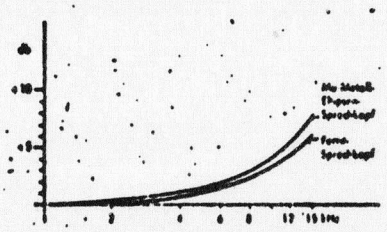


Abb. 4
Erforderliche Aufsprechüberhöhung für Sprechköpfe bei einer Bandgeschwindigkeit von 76,2 cm/s

Dies trifft jedoch nur bei einer Bandgeschwindigkeit von 76,2 cm/s zu. Schon bei einer Bandgeschwindigkeit von 38 cm/s ist die erforderliche Aufsprechüberhöhung wenigstens zur Zeit noch für den Mu-Metallsprechkopf bei den hohen Frequenzen günstiger. Dies hat folgende Ursache: Die erforderliche Aufsprechüberhöhung zur Erzielung einer bestimmten Magnetisierung auf dem Bande in Abhängigkeit von der Frequenz ist nach kurzen Wellenlängen zu größer werdender Entmagnetisierung durch die Feldverteilung vor dem Spalt bedingt. Die Größe dieses Feldes ist durch zwei Faktoren bestimmt. Die im Kopf auftretenden Wirbelstromverluste verursachen eine Verkleinerung des wirksamen Spaltfeldes mit zunehmender Frequenz. Da die Wirbelstromverluste im Mu-Metall um mehrere Zehner-Potenzen größer sind als bei den Ferriten (siehe Tabelle 2, Gütefaktoren), treten diese frequenzabhängigen Feldverluste bei dem Ferritsprechkopf nicht in Erscheinung. Dagegen sind die wellenlängenabhängigen Verluste, die durch die Breite des wirksamen Feldes vor dem Spalt gegeben sind, bei den Mu-Metallköpfen kleiner als bei den Ferritköpfen, weil die wesentlich größere Permeabilität von Mu-Metall das wirksame Aufzeichnungsfeld auf einen kleineren Raum begrenzt. Bei den Ferritsprechköpfen tritt durch die größere Ausdehnung des Feldes bei kurzen aufgezeichneten Wellenlängen eine Teillöschung der Aufzeichnung ein, da diese das wirksame Feld noch nicht vollständig verlassen hat, bevor die nächste Halbperiode das Feld vor dem Spalt umkehrt. Die Addition dieser beiden Ursachen für die notwendige Aufsprechüberhöhung bedingt ein Überschneiden der Aufsprechkurven für den Mu-Metall- und Ferritsprechkopf bei einer Bandgeschwindigkeit von 38 cm/s, während bei der Bandgeschwindigkeit von 76 cm/s die wellenlängenabhängigen Verluste des Ferritsprechkopfes noch nicht ins Gewicht fallen. Durch den breiteren Feldverlauf bei dem Ferritsprechkopf fehlt eine Aufzeichnung der Vormagnetisierung, die beim Mu-Metallsprechkopf noch nachgewiesen werden kann. Für den Ferritsprechkopf besteht natürlich genau so wie für den Löschkopf die Möglichkeit, die Vor-

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magnetisierungsfrequenz bis etwa 300 kHz heraufzusetzen, wodurch mit Sicherheit das Auftreten von Differenztönen zwischen der Modulation und der Vormagnetisierungsfrequenz vermieden wird.

c) Hörköpfe

Die Eigenschaften eines Hörkopfes sind im wesentlichen neben der Empfindlichkeit, die eine Funktion der Spalttiefe und des rückwärtigen magnetischen Schlusses ist, durch die auftretenden Verluste bestimmt.

1. Elektrische Verluste

Hier sind die Ferrithörköpfe den Mu-Metallhörköpfen überlegen, wie aus der Abb. 5 hervorgeht, da

Abb. 5
Elektrische Verluste der Hörköpfe

die Wirbelstromverluste bei der Ferriten in dem in Betracht kommenden Frequenzbereich weit unter 0,1 db liegen, während bei den Mu-Metallhörköpfen diese Verluste nicht mehr vernachlässigt werden können.

2. Spaltverluste

Die Spaltverluste eines Hörkopfes lassen sich in guter Näherung durch die Spaltfunktion

$$f(\lambda) = \frac{\sin \pi d/\lambda}{\pi d/\lambda}$$

angeben, wenn man die erste Nullstelle als effektive Spaltbreite annimmt. Diese effektive Spaltbreite ist bei den Mu-Metallköpfen etwa gleich der mechanischen Spaltbreite (14 $\mu$). Bei den Ferrithörköpfen, bei denen das Material FXC III A zur Verwendung gelangt, mit einer Anfangspermeabilität von 1600 gegenüber 12000 bis 17000 bei Mu-Metall, ergibt sich allgemein eine höhere effektive Spaltbreite als der mechanischen Spaltbreite entspricht. Dabei hängt die gemessene effektive Spaltbreite sehr wesentlich von der mechanischen Bearbeitung der Spaltkanten ab. Neben der durch die Lufteinschlüsse bedingten Vergrößerung der effektiven Spaltbreite entsteht durch das Schleifen der Spiegelfläche des Kopfes an den Spaltkanten leicht eine Abrundung, wenn die Folie zu weich ist und die Ferrite ausbrechen. Es ist deshalb sehr wichtig, ein geeignetes Folienmaterial zu finden, das etwa die gleiche Härte wie die Ferrite selbst hat. Die bisher verwendete Bronzefolie genügt in dieser Beziehung den Anforderungen noch keineswegs. Trotzdem sind die damit erzielten Ergebnisse den bisherigen Mu-Metallköpfen praktisch gleichwertig bezüglich der Auflösung der kurzen Wellenlängen auf dem Band oberhalb von 30 $\mu$ (Abb. 6). Es ist hier noch mit einer wesentlichen Verbesserung der Auflösung zu rechnen, wenn man nach der Fertigstellung der mechanischen Bearbeitung der Ringhälften eine Glasierung der Spaltflächen in Foliendicke vornimmt. Die Versuche hierüber sind jedoch zur Zeit noch nicht abgeschlossen. Es ist aber sicher anzunehmen, daß danach die Ferrithörköpfe auch für eine Bandgeschwindigkeit von 38 cm/s eine praktisch gleiche EMK-Kurve wie die Mu-Metallhörköpfe haben werden, wobei eine etwas kleinere mechanische Spaltbreite erforderlich ist. Dagegen erscheint es auf Grund der bisherigen Ergebnisse unwahrscheinlich, daß mit Ferrithörköpfen auch bei Bandgeschwindigkeiten vor. 19,05 cm/s und niedriger befriedigende Ergebnisse erzielt werden können.

3. Frequenzunabhängige Verluste

Zu den oben genannten Verlusten treten noch die frequenzunabhängigen Verluste des Hörkopfes, die durch die begrenzte Größe des magnetischen Widerstandes im vorderen Spalt bedingt sind. Dieser Spalt stellt einen Nebenschluß für den aus dem Band in den Kopf eintretenden Fluß dar. Er liegt bei Mu-Metallhörköpfen in der Größenordnung von 30% des Nutzflusses bei mittleren Wellenlängen und kann beim Ferrithörkopf trotz des größeren magnetischen Widerstandes des Ringes durch Herabsetzung der Spalttiefe auf mindestens den gleichen Wert gebracht werden. Dies ist bei den Ferrithörköpfen ohne wesentliche Nachteile möglich, da die Härte des Materials keine Veränderung der Kopfeigenschaften über lange Zeiträume zuläßt. Es wird dadurch praktisch die gleiche Empfindlichkeit erzielt wie mit dem neuen Hörköpfen der AEG.

In Abb. 7 sind die Verlustwiderstände von Mu-Metall- und Ferrithörköpfen in Abhängigkeit von der Frequenz aufgetragen. Die Größe der Verlustwiderstände bestimmt das Widerstandsrauschen des Kopfes in dem jeweils betrachteten Frequenzbereich. Wie aus der Abbildung ersichtlich, ist hier der Ferrithörkopf wesentlich günstiger, wenn dies auch in Zusammenstellung mit dem Wiedergabeverstärker V 67 meßmäßig nicht in Erscheinung tritt, da das Rauschen der Eingangsröhre EF 40 im gesamten Frequenzbereich gegenüber dem Kopfrauschen noch überwiegt. Für Spezialzwecke, d. h. für hohe Bandgeschwindigkeiten (ungefähr 2 m/s), und einen

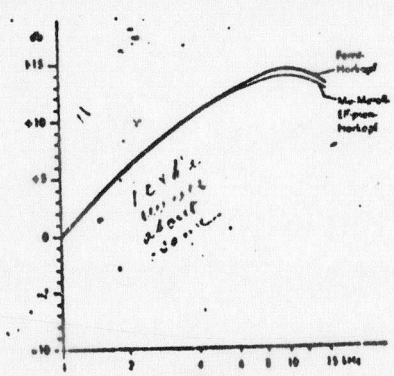


Abb. 6
EMK-Kurven der Hörköpfe bei 76,2 cm/s Bandgeschwindigkeit

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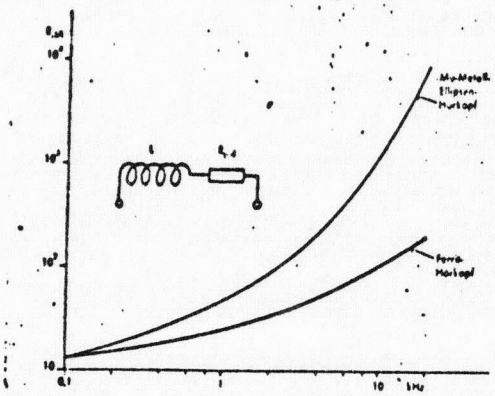


**Abb. 7**
**Reihenverlustwiderstand der Hörköpfe**

Frequenzbereich bis etwa 100 kHz dürfte das Kopfrauschen nicht mehr zu vernachlässigen sein, ganz abgesehen davon, daß für diese Frequenzen der Ferrithörkopf auch bezüglich seiner EMK auf Grund der dann beträchtlichen elektrischen Verluste eines Mu-Metallkopfes bessere Ergebnisse zeitigen wird.

### d) Betriebserfahrungen mit Ferritköpfen

Seit einem Jahr ist im Mittelwellen-Sendemagnetofon des NWDR Hamburg ein mit Ferritköpfen bestückter Kopfträger eingesetzt. Zum gleichen Zeitpunkt wurde auf dem Nebenplatz ein Mu-Metallkopfträger neu bestückt. Während die Mu-Metallköpfe schon nach etwa 500 Betriebsstunden wegen Durchschliffs der Spaltflächen aus dem Betrieb gezogen werden mußten, ist an dem Ferritkopfträger während der gesamten Zeit keine Neueinmessung der Verstärker notwendig geworden und ein meßbarer Abschliff konnte an keinem Kopf festgestellt werden, obwohl absichtlich auch das Rückspulen ohne Abheben des Bandes von den Köpfen erfolgte. Es ist sehr wahrscheinlich, daß die Lebensdauer der Ferritköpfe mindestens das Zehnfache der Mu-Metallköpfe beträgt. Zur Zeit sind im NWDR Hamburg vier Magnetofone mit Ferritkopfträgern ausgestattet, um ihre zeitliche Konstanz in größerem Umfange zu erproben. Es werden in Kürze auch den anderen Funkhäusern des NWDR mit Ferritköpfen bestückte Kopfträger zur Verfügung gestellt werden. Schwierigkeiten mit den Ferritköpfen sind während des Betriebs einmal dadurch entstanden, daß sich statische Ladungen auf den Massebändern bemerkbar machten, die durch den hohen spezifischen Widerstand der Ferrite verursacht wurden. Eine gute Erdung der Ringhälften in unmittelbarer Nähe der Spiegelflächen führte jedoch zu einer vollständigen Unterdrückung dieses Effektes. Zur Verringerung der elektrischen Verluste in den Köpfen wurde im Tonträgerlabor eine Trolitulhalterung entwickelt, die neben der Erreichung einer optimalen Güte auch eine leichte Montagemöglichkeit aller drei Kopfarten gewährleistet. Die Herstellung der Köpfe aus Ferriten erfordert hohe Präzision der Schleifeinrichtungen als Voraussetzung für befriedigende Ergebnisse. Auf Grund der großen Härte des Materials ist die Fabrikation jedoch auch dann nicht ganz einfach, und es muß mit einem Ausschuß von etwa 50 % gerechnet werden. Die Herstellungkosten bestehen zum überwiegenden Teil aus aufgewandter Arbeitszeit, während die Materialkosten nicht ins Gewicht fallen. Es sei noch bemerkt, daß die Ferritköpfe vor Stoßbeanspruchung zu schützen sind.

### Zusammenfassung:

Die Entwicklung der Ferritköpfe im Tonträgerlabor des NWDR hat heute einen Stand erreicht, der u. E. ihre Einführung in den Rundfunkbetrieb für eine Bandgeschwindigkeit von 76,2 cm/s ermöglicht. Die Doppelspalt-Löschköpfe stellen ohne Zweifel einen wesentlichen Fortschritt in ihren Eigenschaften dar. Die Ferritsprechköpfe sind den bisherigen Sprechköpfen mindestens gleichwertig und bringen eine Verbesserung des Modulationsrauschens von > 5 db. Durch Heraufsetzung der Vormagnetisierungsfrequenz ist ohne Schwierigkeiten auch eine völlige Unterdrückung der Differenztöne möglich. Die Ferrithörköpfe sind in ihrem EMK-Verlauf bei 76,2 cm/s den bisherigen Mu-Metallköpfen (Ellipsenköpfe) fast gleichwertig und im Zusammenhang mit dem Wiedergabeverstärker V 67 ist eine Entzerrung bis 15 kHz einstellbar, wenn auch auf Grund der konstanten elektrischen Eigenschaften des Ferrithörkopfes (Selbstinduktion unabhängig von der Frequenz) eine Änderung der Gegenkopplung eine weitere Verbesserung ermöglicht. Hervorzuheben ist die große zeitliche Konstanz und Lebensdauer der Ferritköpfe, die die der bisherigen Köpfe bei weitem übertrifft. Die Entwicklung der Ferrit-Sprech- und Hörköpfe für eine Bandgeschwindigkeit von 38,1 cm/s ist zur Zeit noch nicht abgeschlossen, doch scheint auch hier eine einwandfreie Lösung möglich. Der Sprechkopf kann auch schon in seiner jetzigen Form für diese Geschwindigkeit eingesetzt werden, sofern man die Aufsprechüberhöhung beim Übergang von 76,2 cm/s auf 38,1 cm/s Bandgeschwindigkeit mit umschaltet, wie es auch für die Mu-Metallköpfe geplant ist. Bei den Hörköpfen ist eine Umschaltung und Entzerrung auch erforderlich, doch liefern die jetzigen Ferrithörköpfe bei der niedrigen Geschwindigkeit einen konstanten Ausgangspegel am V 67 lediglich bis 12 kHz. Ein Bericht nach Abschluß der Entwicklung der Ferrit-Hör- und Sprechköpfe für 38,1 cm/s Bandgeschwindigkeit folgt in der nächsten Zeit.

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PLAINTIFF'S EXHIBIT 151-D.

Dec. 29, 1959 G. ROSENBERGER ET AL 2,919,312

MAGNETIC HEADS

Filed March 16. 1954

Fig. 1

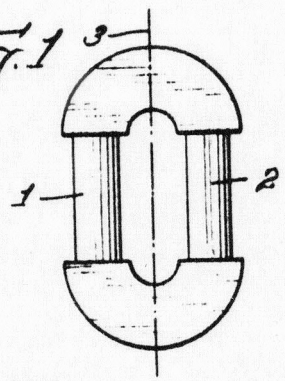



Fig. 2

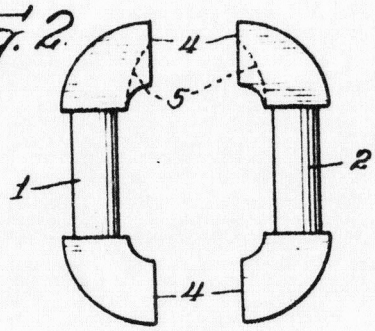



Fig. 3

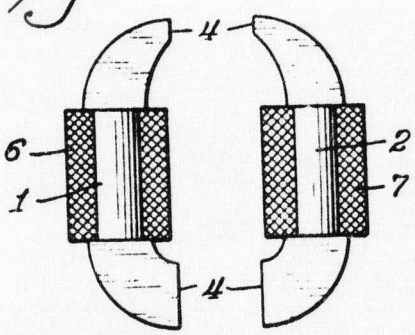



Fig. 4

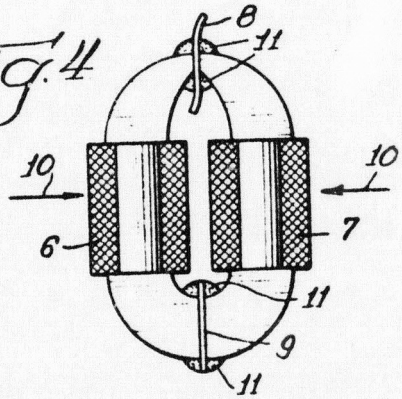



Fig. 6

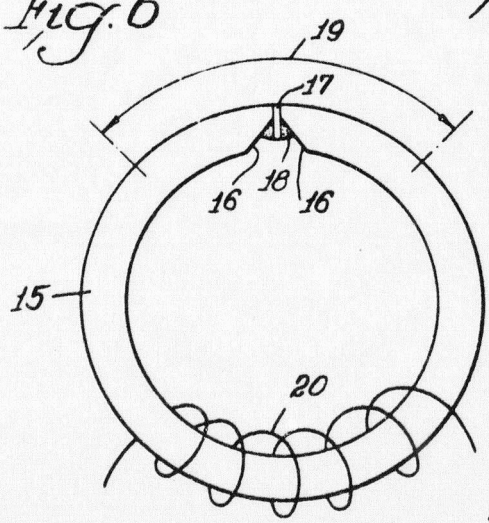
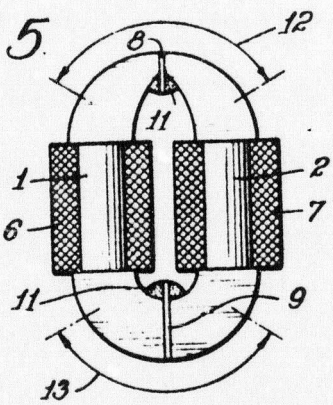



Fig. 5




Inventors
Georg Rosenberger
and Helmut Neumann
By [signature] atty.

PLAINTIFF'S EXHIBIT 151-D

United States Patent Office

2,919,312

Patented Dec. 29, 1959



2,919,312

# MAGNETIC HEADS

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Application March 16, 1954, Serial No. 416,673

Claims priority, application Germany March 20, 1953

3 Claims. (Cl. 179—100.2)

This invention is concerned with a magnetic head comprising a core of sintered ferromagnetic material of ceramic nature, for example ferrite, having a relatively narrow gap, especially for longitudinal magnetization and for coaction at one side thereof with a magnetic carrier such as a tape or the like. The magnetic head may be a record head or a pickup head or an erase head.

Magnetic heads comprising cores made of sintered metal or metallic alloys, for example, ferrite, instead of being made of laminated sheet material, present due to their relatively low electric conductivity and good magnetic properties considerable advantages at higher frequencies. As further advantages of such structures may be mentioned considerably greater resistance of the pole pieces formed by the cores, against wear, due to the greater hardness of the material, and decreased residual magnetism. Magnetic heads of this type also exhibit advantages so far as magnetic and mechanical properties are concerned. Erase heads having cores made of such ferromagnetic material provide lower eddy current losses than laminated cores. Prior erase heads with laminated cores assumed relatively high temperatures when operated with frequencies from about 60–100 kilocycles and relatively high current. Such heating can be reduced by using the new cores.

The drawbacks arising in the fabrication of the cores reside in difficulties due to the brittleness of the sintered oxide-ceramic material, especially when it is desired to form narrow gaps of a width on the order of about 10 microns, for pickup and record heads, or gaps of a width of about 0.2 millimeter for erase heads. An exact formation of the gap by grinding, sawing, milling and the like was found impossible because the hard ceramic core material cracks, causing chipping off of parts at the edges of the gap to be formed. It was for these reasons impossible to produce gap surfaces having sharp and well defined edges. The effective gaps were accordingly badly defined and the gap width became generally wider than is permissible for the recording of the highest audio frequencies.

It was until now, for the foregoing reason impossible to fully utilize the favorable electrical, mechanical and magnetic advantages of the sintered materials, and magnetic heads comprising such materials were accordingly practically no better than heads comprising laminated cores.

The magnetic heads according to the invention are made by production and machining steps which result in satisfactory gaps as well as other desirable electrical, magnetic and mechanical properties.

In accordance with one object, the invention proposes to produce a suitably shaped, for example, ring-shaped or an oval-shaped or a U-shaped core forming two limbs which are cross-sectionally circular for receiving coil means, by cutting or sawing a unitary sintered member to form two halves, or by molding or pressing each half individually; thereafter grinding and interiorly shaping, that is, pointing, rounding or angularly shaping the surfaces of the two halves which are to define pole



pieces to form the gap; thereupon placing the coils upon the two core halves; and thereafter assembling the two halves and securing them together with the pole pieces properly aligned to form the gap.

In accordance with another object and feature, the invention proposes to produce a core of the ferromagnetic material noted before, such core forming the gap, and to dispose between the pole pieces, that is, within the gap, a thin foil-like or platelike filler material of substantially similar hardness as the core, for example, in the case of record or pickup heads, material such as molybdenum or tungsten, quartz or glass, or electrically and magnetically substantially nonconductive ceramic material such as porcelain or the like. Material having low electric and magnetic conductivity, such as quartz, glass or porcelain is especially favorable as a filler for the gaps of erase heads. The outer surfaces of the pole pieces are thereupon ground at least at the region which is to coact with or be contacted by the magnetic carrier or tape. This final grinding of the core in the vicinity of the gap which contains the filler material of approximately the same hardness as the pole piece material makes it possible to produce a satisfactory gap because the effective gap-defining edges are supported by the filler, chipping off of the material as it always occurs if it is attempted to grind the gap edges to the desired shape prior to the joining of the pole pieces being in this manner prevented.

The magnetic head produced in this manner and comprising the sintered core has a wholly satisfactorily limited and well defined very narrow working gap facing the the magnetic carrier.

The invention will now be described with reference to the accompanying diagrammatic drawings wherein

Fig. 1 shows an example of an oval-shaped sintered ferromagnetic core body in elevational side view;

Fig. 2 illustrates two halves of the core to be made; each half may be individually formed or obtained by cutting the body of Fig. 1;

Fig. 3 represents the two halves of the core after shaping and provided with the associated coils;

Fig. 4 illustrates the joining or assembling of the two halves of the core by the use of a gap filler material;

Fig. 5 illustrates the assembled core structure having the surfaces of the gap-forming pole pieces shaped by final grinding; and

Fig. 6 shows an example of a coil-carrying core for an erase head.

Referring now to the drawings, Fig. 1 indicates an elevational diagrammatic side view of an example of an oval-shaped sintered ferromagnetic core as it may be used for producing a magnetic pickup or record head according to the invention. Ring-shaped or equivalently shaped cores may of course be used to equal advantage. The core is not exactly of ellipsoid shape but is provided with straight parallel limbs 1 and 2, which may be cross-sectionally circular, for receiving the required coils.

The core is in suitable manner and by suitable means severed along the median dot-dash line 3, for example, by cutting with a saw, to produce the two separate halves shown in Fig. 2.

It is of course not absolutely necessary to start with a core body such as indicated in Fig. 1; each of the two halves shown in Fig. 2 may, for example, be individually formed by suitable moldings or pressing.

The surfaces 4 of the two pole pieces which will define the gap, are thereupon planed by suitable grinding, for example, by rubbing them against very fine emery paper placed upon a support, to make them plane and extending in parallel.

The next step requires, in accordance with the invention, suitable angular machining or forming to provide pointed

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or inclined or rounded ends extending generally along the lines 5 in Fig. 2.

The coils 6 and 7 are thereupon placed upon the straight limbs 1 and 2, respectively, to form the parts shown in Fig. 3.

The pole pieces of the two halves of Fig. 3 are thereupon suitably assembled to form the final core structure.

As illustrated in Fig. 4, a filler material 8 and 9 may be interposed between the faces of the inwardly facing ends of the core halves. Lateral pressure is suitably applied in the direction of the arrows 10. The inwardly facing ends of the two halves of the core are secured together, for example, by means of a suitable adhesive or cement 11. The upwardly disposed inwardly facing ends of the core halves, as seen in the figures, form the magnetically effective pole pieces having a gap containing the filler 8. The joined lower ends containing the filler 9 absorb shearing stresses.

The gap filler material 8 and 9 is, for record or pickup heads, preferably foil or plate-shaped and approximately 10 microns thick, its width corresponding to the width of the desired gap.

At least the gap filler material 8 is preferably of a hardness corresponding substantially to that of the sintered core and pole pieces, for example, molybdenum or tungsten or quartz or glass or electrically and magnetically nonconductive material such as porcelain or the like. Similar material may be used for the filler 9, but its kind is not as critical because the corresponding gap merely serves for absorbing shearing stresses, having no coaction with the magnetic carrier. The corresponding gap therefore does not have to be of the quality of the other gap which is effective in the recording or the pickup operation, respectively, for which the head may be used.

A self-hardening resinous material known in Germany as Araldittharz G may be used for the adhesive or cement 11.

The cement is permitted to solidify and the resulting structure is then ground along the outer surfaces comprising the gap fillers 8 and 9, at least within the regions indicated in Fig. 5 by the arrows 12 and 13. The grinding region along the arrow 12 corresponds to or forms the surface which is contacted by or coacts with the magnetic carrier, for example, a magnetic tape.

The interposed gap filler or foil 8 and if desired also 9 are from about 10 microns to about 15 microns thick.

The erase head shown in Fig. 6 comprises a sintered ring-shaped core 15 having pole pieces forming a gap about 0.2 millimeter wide. The gap may be formed by suitable sawing, milling, grinding or the like or may be formed in the pressing or molding operation. The pole pieces are thereupon suitably machined to form the wedge-shaped cutout 16. Such cutout may of course be formed in the molding of the core body.

The gap formed by the pole pieces is in foil or plate form, of material having a relatively low electric conductivity and a hardness corresponding substantially to that of the pole pieces. Glass, quartz or electrically substantially nonconductive material such as porcelain may be used. The filler material 17 projects into the wedge-shaped widened portion 16 and is secured by the adhesive or cement 18, which may be of the previously mentioned self-hardening resinous type. After the cement 18 has set, the surface of the pole pieces, which will coact with the magnetic carrier, tape or the like, is ground as before, for example, along an area indicated by the arrow 19, thus also correspondingly grinding the gap filler 17. Numeral 20 indicates the erase winding which is provided in known manner.

The gap filler is in each embodiment of a hardness which corresponds substantially to that of the corresponding sintered ferromagnetic pole pieces. Accordingly, after the final surface grinding along the areas 12 in Fig. 5 and 19 in Fig. 6, there will in each case result a uniform smooth arcuate continuous surface for magnetic



coaction with a magnetic carrier or tape. If the gap filler were softer than the pole pieces, a groove would be formed at the gap; if harder material were used, it would form a ridge. The gap filler specified assures in each case the smooth arcuate active pole and gap surface.

The erase head made in accordance with the invention, provided with the gap filler of relatively low electrical conductivity keeps the eddy current losses at high audio frequencies and with high-frequency current of about 60–100 kilocycles at a minimum.

All operations may be carried out by known means and in known manner.

The respective magnetic core structures produced as described may be embedded in a suitable molding mass contained in a suitably shaped shielding cup.

It may be mentioned in conclusion that certain features of the invention may be practiced independent of certain other features. It is possible, for example, to produce a core for a magnetic record or pickup head by the operations disclosed herein which comprise the steps of forming the core body of two halves, shaping the surfaces at the opposite ends of each half by suitable grinding, thereafter placing the coils on the respective limbs of the two halves, and thereafter assembling the two halves, finally shaped as shown in Fig. 3, to form the desired core structure. A filler may or may not be provided in the magnetically active gap and the filler, if provided, may be of a desired and suitable material. The gap filler material described, having a hardness corresponding substantially to that of the sintered core material, may of course be provided in gaps formed by cores produced in any suitable and desired manner which may be different from the specific manner of producing the cores as disclosed herein.

What is believed to be new and desired to have protected by Letters Patent is defined in the appended claims.

We claim:

1. A magnetic head for coaction with a magnetic carrier comprising a ferrite core having two coil-carrying limbs, arcuate extensions projecting respectively from said limbs integral therewith to form coacting pole pieces separated by a gap, a filler disposed in said gap, said filler being made of a material selected from the class of materials consisting of glass and quartz and molybdenum and ceramic material such as porcelain, the hardness of such filler material corresponding substantially to that of said pole pieces, and cementing means outside of said gap for firmly bonding together said pole pieces with said filler therebetween to form a unitary core structure, the arcuate outer surface formed by said joined pole pieces being ground to form the working face for magnetic coaction with the magnetic carrier, said filler preventing chipping of said pole pieces during said grinding to form sharply defined edges forming the gap containing said filler.

2. The structure defined in claim 1, wherein the width of said gap is on the order of about 10 microns to about 15 microns.

3. The structure as defined in claim 1, wherein said gap is the sole and exclusive gap in said core structure, the width of said gap being on the order of about 0.2 millimeter.


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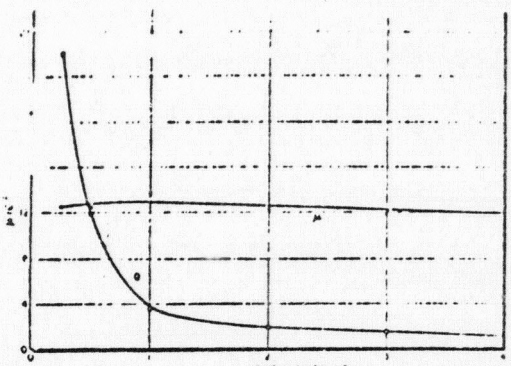


Fig. 1: Permeability and Q as a function of frequency

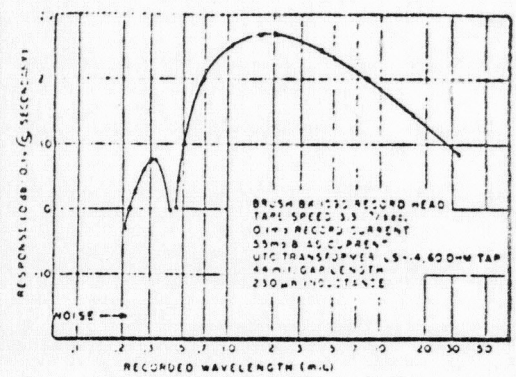


Fig. 2: Response of ferrite head with glazed gap

# Ferrite Heads for Recording In the Megacycle Range

*Ferrites are found to have resolutions comparable to metallic heads. Problem of wear, particularly at gap edges, is minimized by glazing techniques*

By W. R. CHYNOWETH

BECAUSE of their relative hardness and low losses, ferrites were early considered a potential core material for magnetic recording heads. As early as 1948 some ferrite heads with an effective gap of around .75 mil were built and tested. Since that time ferrite heads have appeared commercially, mostly for pulse applications where the head was spaced from the medium. In the field of contact heads, ferrites have not fared quite so well. Early thoughts seemed to indicate the following disadvantages:

1) difficulty in fabrication due to hardness

2) brittleness leading to easy chipping

3) poor resolution due to granularity

With the possible exception of the chipping, the above disadvantages have not proven serious. Ferrites can be molded and then ground and lapped, and this process could well prove to be more economical for production than the handling of thin metallic laminations.

The work described in this article was done as part of a wide band magnetic recording development. It was desired to build heads which could be operated at bias or signal frequencies in the low megacycle range with as high a resolution as possible. Ferrites seemed to satisfy the high frequency requirements.

It was thought at that time that the loss of resolution due to rough gap edges caused by granularity of the ferrite would be the most serious problem; therefore a materials development program was initiated to produce a more homogeneous and dense ferrite with satisfactory magnetic and physical

W. R. CHYNOWETH, Electronics Lab., General Electric Co., Electronics Park, Syracuse, N. Y.

Fig. 3: High resolution ferrite head gaps

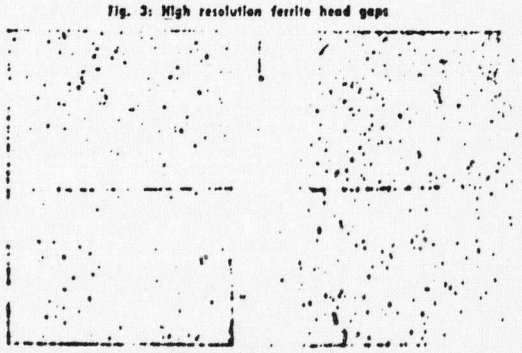
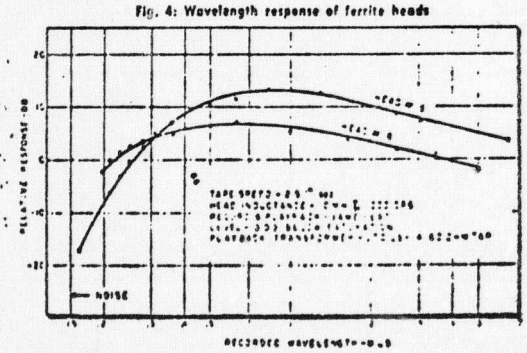


Fig. 4: Wavelength response of ferrite heads



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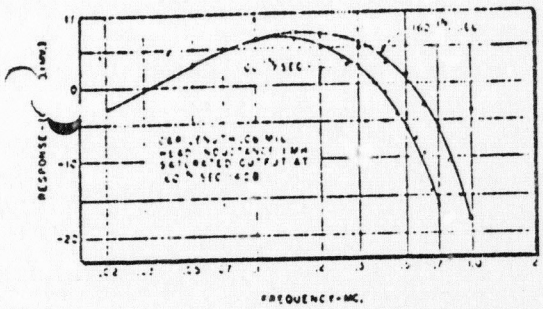

Fig. 5: Response curves for head No. 15 at 100 and 160 ips

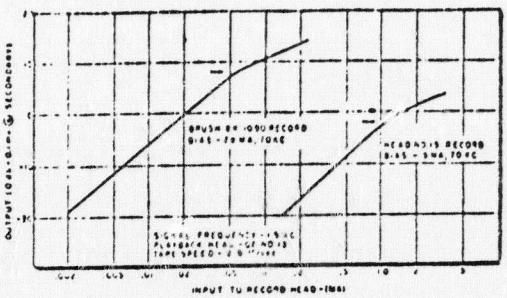

Fig. 6: Comparative curves for ferrite and Brush BK1090 heads

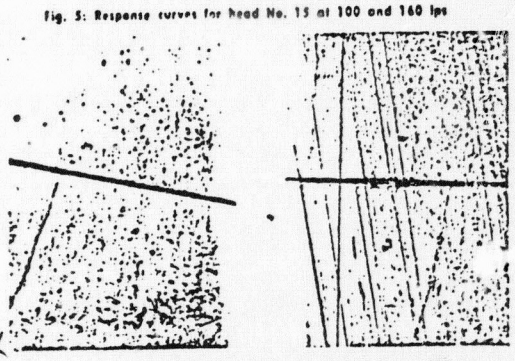

Fig. 7: Wear (l) after 35 hrs. at 100 ips, (r) after 83 hrs. at 100 ips

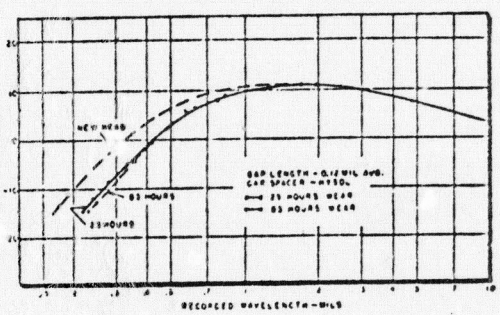

Fig. 8: Effect of wear on resolution of ferrite head at 100 ips

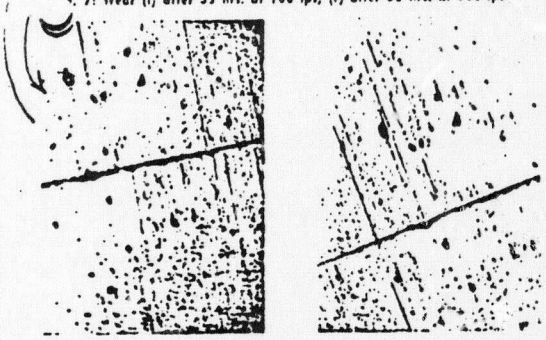

Fig. 9: Glazed head showed great improvement in wearing qualities

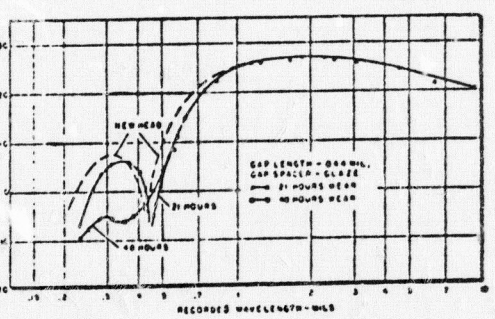

Fig. 10: Wavelength responses taken after 21 and 48 hrs. of wear

properties for use in heads. In terms of the original aims, this program was quite successful. Ferrites were produced with satisfactory permeabilities and Q to be used as playback heads up to 5 mc: Fig. 1 shows a graph of permeability and Q as a function of frequency. That these ferrites had the necessary physical properties to make sharp recording eadsgaps is shown in Fig 9. It will noted that the ferrite is free from ge voids and blow holes and that the gap edges are quite straight and uniform. Additional evidence of the sharpness of the gap edges is shown in Fig. 2. The sharpness of the null is a characteristic of relatively sharp and parallel edges.

The head just described (Fig. 2) is not a high resolution head; it could be used out to 0.5 mil wavelength. Photomicrographs of two higher resolution heads are shown in Fig. 3. It will be noted that the gap edges appear straight and parallel and free from large irregularities. The sharpness of a gap edge is significant only when related to the recorded wavelength; from this point of view the edges are not sharp and straight but have irregularities which are comparable to the gap length. The minimum gap length for head #15 (Fig. 3) is around .06 mil and for head #17 is around .03 mil, therefore the irregularities, although relatively large, are quite small on an absolute scale. The wavelength response of these heads is shown in Fig. 4; the problem of gap alignment at very short wavelengths was dodged by recording and playing back on the same head. There were some differences in output between the heads but datagon such factors as front and back gap reluctance and the effect of potting strains was not sufficient to attach specific significance to these output variations. It is significant that the curves do not show the sharp null of head #10. This is evidence that the gap edges are less sharp relative to the recorded wavelengths at which the null should occur. In Fig. 5 are shown frequency

(Continued on page 169)

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PLAINTIFF'S EXHIBIT 151

## Ferrite Heads

(Continued from page 83)

response curves for head #15 taken at 100 and 160 ips tape speeds. It will be noted that the improvements in frequency response due to the increase in speed is not as great as one would expect. There was evidence that an air film between the head and tape was produced at 160 ips. A spacing loss of .02 mils will account for the decreased resolution.

These ferrite heads have a resolution which is at least as good as any of the metallic heads which have been made available for comparison at this time. A discernible output was noted at .125 mil wavelength. In terms of the equalization required, these heads would be useful to at least .2 mil recorded wavelength. The relatively low output would put a severe requirement on the associated amplifiers.

It has been demonstrated that ferrite heads with good short wavelength resolution can be fabricated. However, they are not, at this stage of development, a satisfactory general purpose head at these resolu-

As a record head they have the following shortcomings: relatively low saturation flux density, low Curie temperature, and erosion of the gap edges. Playback heads suffer from erosion at the gap edges.

The Curie temperature for these particular ferrites was fairly low, around 65°C. The use of these heads as record heads in an ambient temperature of 25°C is marginal; the rise due to combined bias and record current may cause the total temperature to exceed the Curie temperature. They would obviously not satisfy military specifications. This limitation does not appear to be fundamental. A further material development should raise the Curie temperature some, although perhaps at the sacrifice of some of the other properties.

The low saturation flux density is not a serious handicap in conventional playback heads, or in wide gap record heads. In record heads which have gaps as small as those described above, saturation becomes a serious problem. Since the record-[illegible] access in a gap type head depends upon leakage flux, and since the relative amount of leakage flux with a very fine gap is very small, it follows that the flux density in the core, and especially the gap edges must be high. It has been found that with these ferrites and gap lengths saturation does occur. In Fig. 6 are


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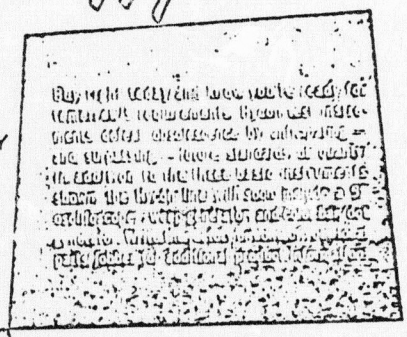
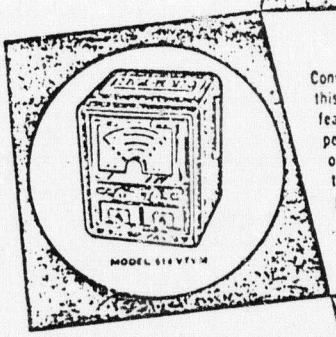
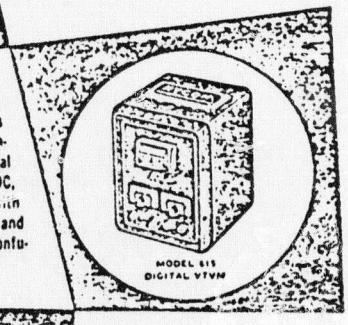
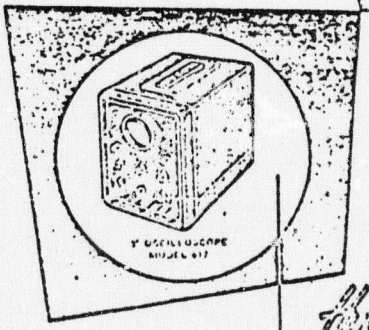




Convenience at unprecedented low cost sums up this rugged, serviceable instrument. Hycon plus features include: 21 ranges (28 with peak-to-peak scales), large 6½" meter, 3% accuracy on DC and ohms, 5% on AC, frequency response to 250 mc with accessory crystal probe. Test probes stow inside case, ready to use.

Ideal for production-line testing and laboratory work, this new VTVM provides direct readings without interpolation. Features illuminated digital scale with decimal point and polarity sign; 12 ranges (AC, DC, ohms); frequency response to 250 mc with auxiliary probe; accuracy: 1% on DC and ohms, 2% on AC. Cuts multiple scale confusion and learning curve error.





Designed for both field servicing and laboratory requirements. Features high deflection sensitivity (.01 v in rms); 4.5 mc vertical bandpass, flat ± 1 db, internal 5% calibrating voltage. Small, compact — but accurate enough for the most exacting work. Special flat face 3" CRT provides undistorted trace edge to edge.

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## Ferrite Heads

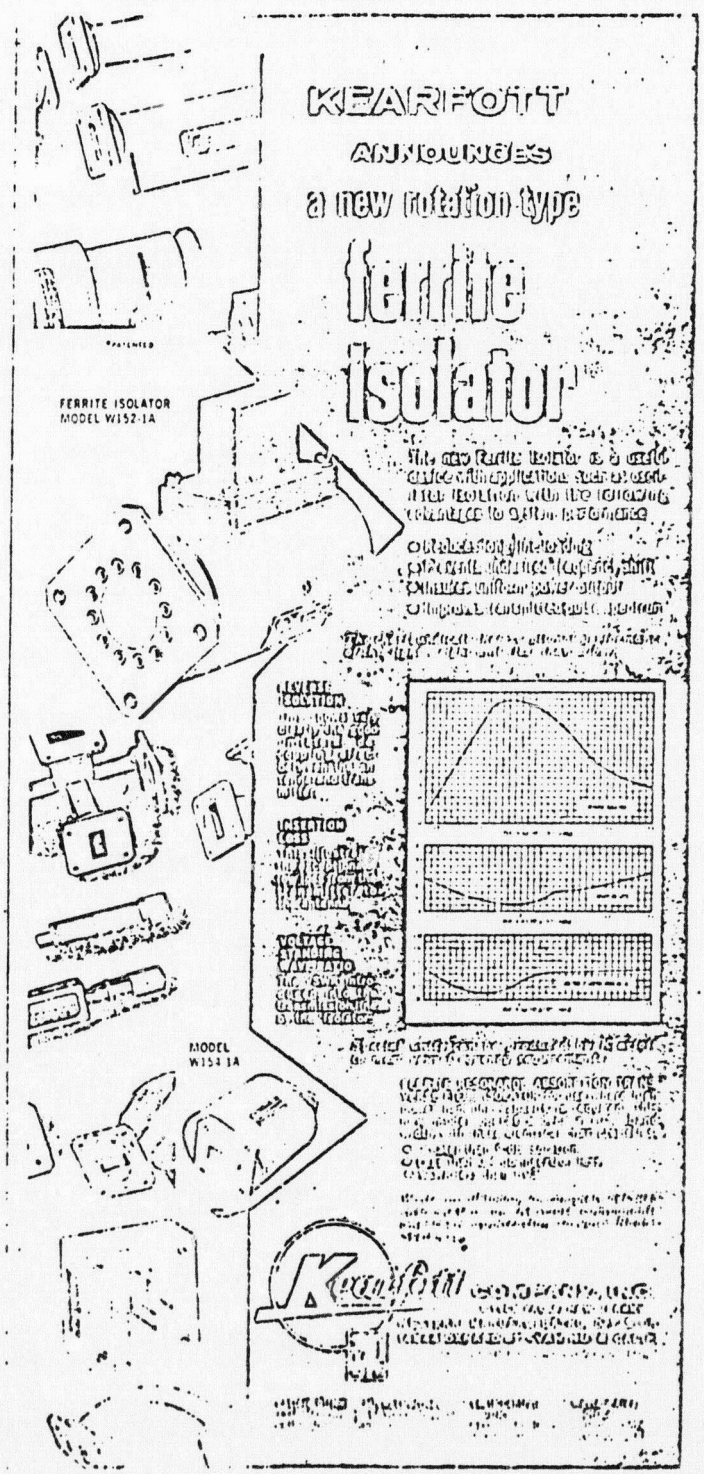
(Continued from page 169)

...son input-output curves for a ferrite head and a Brush BK1090 head. For comparison, the same head was used for playback in each case. It will be noted that the first break in slope occurs at 8 db. output for the Brush head but at −1 db. for the ferrite head. It is not obvious from the data that the Brush head is saturating but certainly the ferrite head is saturating well below tape saturation. This difficulty may be reduced by using materials with higher saturation flux density or by increasing the record gap length. Ferrites as a class tend to have a low saturation flux density so that it appears wider gaps are necessary in ferrite record heads to avoid saturation. It should be emphasized that the use of a wider gap does not mean that a decrease in the sharpness of the gap edge is allowable. The use of a wide gap record head would require special attention to the gap edges in order to retain resolution and to reduce record gap anomalies in the frequency response curve.

### Wearing Qualities

Originally thought of as wear resistant heads because of their hardness, ferrite heads, at present, have wearing qualities which are poor. Wear shows up as an erosion of the tape contact surface. In many instances this erosion may appear all over the surface, but in most cases it is concentrated at the gap edges, the worst location as far as head performance is concerned. Some wear tests were performed on these ferrite heads by running them at a tape speed of 100 ips and then measuring the wavelength response at low tape speeds. A μ-metal head was run at the same time for control purposes.

A ferrite head (Head #5) with a Hysol gap spacer was wear tested for a total of 83 hrs., corresponding to 2,400,000 ft. of tape. The tape used was 3-M type 111 acetate backed tape, and the normal force between head and tape was around 75 grams. No pressure pads were used. In Fig. 7 are shown photomicrographs of the gap edges after 35 and 83 hrs. of wear. The original gap was similar ...ast of head #15 but somewhat ...e irregular. The gap after 35 hrs. of wear shows a definite wearing pattern. There are long scratches which do not appear to be serious except as a possible site for further erosion. After the scratches, erosion appears; actual erosion can be con-



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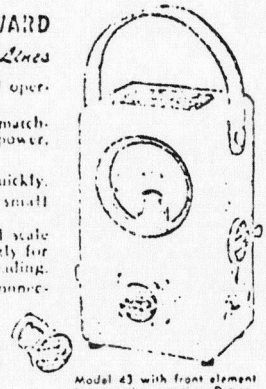

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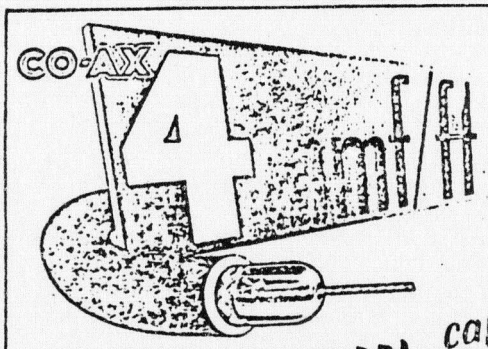


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| C2 | 6.3 | 171 | .64 |
| C22 | 5.5 | 186 | .44 |
| C3 | 5.0 | 197 | .64 |
| C33 | 4.8 | 220 | .64 |
| C4 | 4.6 | 229 | 1.03 |
| C44 | 4.1 | 252 | 1.03 |

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## Ferrite Heads

(Continued from page 171)

sidered in two categories, surface erosion and gap edge erosion. Surface erosion may occur anywhere on a surface where conditions are favorable, and in itself is not detrimental to head performance. The type of erosion which is very serious in ferrite heads occurs at the gap edges. In the 35 hr. photomicrograph, the directional qualities of the gap edge erosion are quite marked. The trailing gap edge, which is directed against the direction of tape travel, is badly eroded while the leading edge, which the tape slides off of, shows very little evidence of erosion. Intuitively this situation seems reasonable. After 83 hrs. of wear the trailing edge is much more badly eroded, and some erosion is starting to occur at the leading edge; the surface erosion has also increased appreciably. In Fig. 8 are shown wavelength response data showing the deterioration in performance as a playback head as the result of wear. It can be seen that the bulk of the deterioration in performance has occurred in less than 23 hrs. of wear. The deterioration then progresses slowly and there is evidence that a usefully long life could be realized at 0.5 mil wavelength if the direction of tape travel was not reversed. If the tape direction is reversed, the uneroded gap edge will erode rapidly so that no portion of the gap would be sharp or well defined. Evidence based on some experience with ferrite heads designed for 1.0 mil useful resolution indicates that, when both gap edges deteriorate, the shortest useful wavelength will be around 1.0 mil.

### *Wearing Properties*

Wear data obtained on both sintered ferrites and single crystals without fabricated gaps indicate that the intrinsic wearing properties are appreciably better than those experienced with fabricated heads. For that reason methods of making the gap area physically more like an ungapped ferrite have been devised. One thought is that when the gap is very short the tape surface cannot get down into the gap region and erode the trailing edge; if the joint were perfect this certainly appears reasonable. It appears unlikely, at this time, that a head with usefully high output will have a short enough gap to successfully resist wear. For this reason it appears that something must be done in the gap or within

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the material in order to decrease this gap edge erosion.

A technique which holds some promise, is to fill in the gap with a [illegible] material which is nonmagnetic, bonds well to the gap faces, and is hard. Such a glazed head (Head #10) was fabricated and subjected to wear tests at 100 ips. A photomicrograph of this head is shown in Fig. 9. Most of the gap was clean and straight when new. After 48 hrs. of wear (1,450,000 ft. of tape) the head has a large amount of surface erosion and the gap edges have eroded somewhat. The directional wear qualities are not very obvious on this head. It can be seen that this head has not eroded as much in 48 hrs. as the previous head had in 35 hrs. In Fig. 10 are shown wavelength responses taken after 21 and 48 hrs. of wear. After 21 hrs. the gap edges were relatively sharp giving a well defined null but there was apparently a loss in resolution. After 48 hrs. the gap edges were irregular enough to almost completely suppress the second peak, although the resolution at wavelengths longer than 0.5 mil was substantially unchanged. Comparison of the wear on heads #5 and #10 indicated that the [illegible]ng technique has apparently increased the resistance to wear.

In conclusion it can be stated that ferrite heads can be constructed which have resolutions, when new, comparable to metallic heads, and that they compare favorably in performance with metallic heads constructed from thin lamination for high frequency use. They are, however, deficient in wearing qualities.

*(This paper was presented at the 1955 I.R.E. Convention.)*

---

### Power Transistor Survey

In the article "Survey of Power Transistors Currently Available," by Rufus P. Turner, Registered Electrical Engineer in the state of California, which appeared in June TELE-TECH, the footnotes to Table 2 were inadvertently omitted in printing and are as follows:

(A) Emitter stabilizing resistor must be bypassed to ground with at least 2000 μfd (6 v) to prevent reduction of power gain.
(B) Input resistance will be higher if emitter stabilization resistor is not heavily bypassed.
(C) [illegible]bilization of dc operating points necessary to prevent collector current runaway.
(D) Non-inductive.
(E) Per collector.
(F) With typical heat sink: 1/16 in. aluminum chassis 6 x 6 x 2 in.
(G) Safe operation up to 70° C ambient.
(H) Common-base circuit only. These data placed in common-emitter section of table for convenience only.


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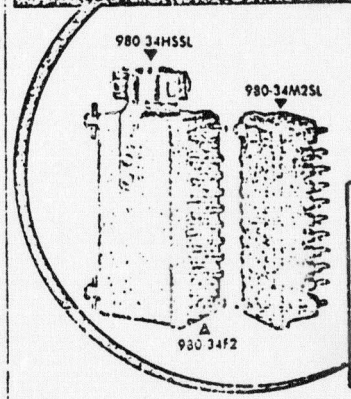


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*Preserves performance of sensitively adjusted contacts *Accessability to wire junctions with simple disassembly of head *Insured electrical and mechanical performance *No limitations on number of contacts *Vibrashock hood construction *Screw Lock Hood Assembly independent of connector.

Double Lead Screw Lock available with 990 and Miniature series

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Aug. 25, 1964 M. CAMRAS 3,145,452

METHOD OF MAKING A MAGNETIC HEAD

Filed March 24, 1958

Fig. 1

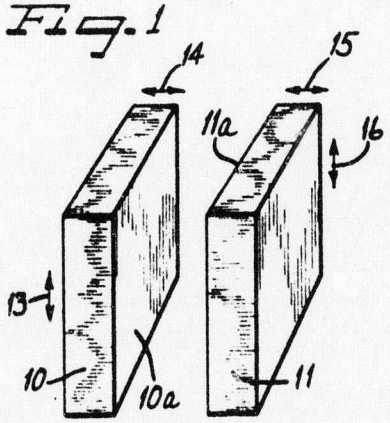



Fig. 2

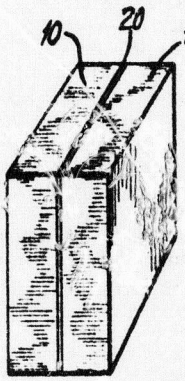



Fig. 3

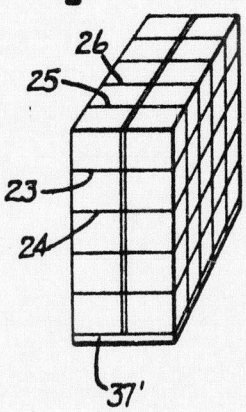



Fig. 4

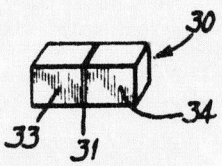



Fig. 5

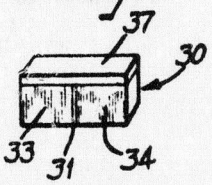



Fig. 6

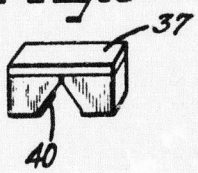



Fig. 7

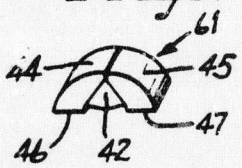



Fig. 9

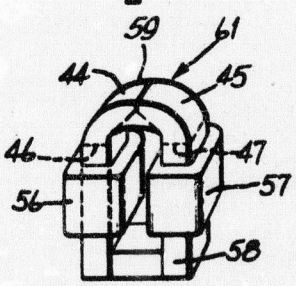
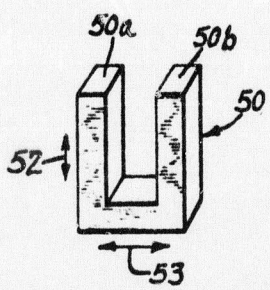



Fig. 8

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by Hill, Sherman, Meroni, Gross & Simpson Attys

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United States Patent Office

3,145,452
Patented Aug. 25, 1964



3,145,452
# METHOD OF MAKING A MAGNETIC HEAD

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Filed Mar. 24, 1958, Ser. No. 723,304
13 Claims. (Cl. 29—155.5)

This invention relates to a method for making a magnetic head, and particularly to a method of making a head of high resistivity material such as ferrite.

It is an object of the invention to provide a method of making a magnetic head having an extremely fine gap, superior high frequency performance and superior wear resistance.

Another object of the invention is to provide a novel method for making a magnetic head particularly adapted for use with ferrite or other high resistivity materials.

Another and further object of the invention resides in the provision of an economical method for producing heads in quantity yet with a very high degree of precision.

Yet another object of the invention resides in the provision of a method of making a magnetic head which accommodates a more precise and less critical assembly procedure than is possible where individual poles of a magnetic head are individually formed.

An important advantage of the present invention resides in the fact that the gap faces are formed to optical flatness while part of a substantially more extended surface area. Very precise optical methods of polishing are available for such extended surfaces which could not be applied to individual gap defining faces of individual poles. The gap material is more readily applied to the more extended surfaces provided by the method of the present invention, and a much more precise gap is formed.

Other objects, features and advantages of the present invention will be apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a perspective view illustrating a pair of blocks of magnetic material having confronting surfaces polished to optical flatness;

FIGURE 2 illustrates the confronting surfaces secured together at their flat surfaces;

FIGURE 3 is a diagrammatic perspective view illustrating the manner in which the assembly of FIGURE 2 is subdivided to provide a plurality of gap subassemblies;

FIGURE 4 is a diagrammatic perspective view of one of the gap subassemblies subdivided as indicated in FIGURE 3;

FIGURES 5, 6 and 7 illustrate steps in the finishing of the gap subassembly of FIGURE 4 into a magnetic transducer head pole assembly;

FIGURE 8 illustrates a yoke for receiving the pole piece assembly of FIGURE 7; and

FIGURE 9 illustrates the final assembly of the subunits of FIGURES 7 and 8.

The present invention is particularly adapted for the forming of magnetic head assemblies from ferrite or high resistivity materal, but can also be used for laminated structures and for applications where thick sections of magnetic material do not have excessive eddy current loss.

In accordance with the illustrated embodiment, a pair of ferrite blocks **10** and **11** have surfaces **10***a* and **11***a* thereof polished to optical flatness. By way of example, each block may be one-half inch square by one-quarter inch high (in the direction of arrow **16**). For quantity production a much larger area is practical. Single crystal ferrite is ideal to avoid the irregularities and granular structure of sintered ferrite, and preferably as indicated in FIGURE 1 the directions of easy magnetization of the single crystal ferrite blocks are those indicated by the arrows **13**, **14**, **15** and **16**. This orientation is preferred



since it is in conformity with the direction of flux paths in the gap subassemblies to be formed from the blocks. With single crystal ferrite material it has been found that much finer gaps can be produced and maintained than are possible with sintered ferrites used in the prior art. However, the same construction is also applicable for less critical work, where fine grain ferrites may be used.

Homogeneous ferrite material, which is not single crystal, or which is of imperfect crystal structure but has the required magnetic qualities (noted below) may be substituted for single crystal material. A preferred gap size is below 5 microns (one micron equals one millionth of a meter), and with care, assemblies with gaps of 0.25 micron or less may be formed.

In assembling the blocks as illustrated in FIGURE 2, a gap spacer **20** may be provided by depositing an evaporated film, for example gold in ¼ micron thickness, on one or both of the polished surfaces **10***a* and **11***a*. Alternatively a layer of foil of proper thickness may be used as a gap spacer, and for even finer gaps the spacer may be omitted entirely.

The mating surfaces **10***a* and **11***a* are then coated with epoxy resin of thin consistency and clamped together until the resin has hardened. Alternatively a low melting point "glass" may be used as an adhesive for the mating surfaces. Metals such as indium which wet and adhere to ferrite may also be used. For the very smallest gaps, cement need not be used on the gap faces.

FIGURE 3 illustrates the manner in which the block of FIGURE 2 may be cut along horizontal and vertical planes such as indicated at **23**, **24**, **25** and **26** to form gap units such as indicated at **30** in FIGURE 4 having gap sections **31** separating ferrite portions such as indicated at **33** and **34**. In cases where cementing at the gap is not used reinforcing is applied to at least one side of each gap unit, for example as shown at **37'** in FIGURE 3, before the cuts are made.

After the step of FIGURES 3 and 4, a reinforcing piece **37** is fastened to one side of the unit **30** so as to allow the removal of material from the other side to reduce the gap facing area as indicated at **40** in FIGURE 6.

As shown in FIGURE 7, non-magnetic reinforcing material as indicated at **42** is fastened in the notch **40** illustrated in FIGURE 6, while tape receiving surfaces **44** and **45** are shaped, and surfaces such as indicated at **46** and **47** are made flat and coplanar to form a pole assembly **61**.

As indicated in FIGURE 8, a yoke **50** is formed of ferrite material, with surfaces **50***a* and **50***b* polished flat and in the same plane to receive surfaces **46** and **47** of the pole piece assembly **61** shown in FIGURE 7. By way of example, the yoke **50** may be formed of single crystal ferrite with the directions of easy magnetization as indicated by the arrows **52** and **53** to conform with the flux path in the yoke. However it is preferable to make the yoke of sintered ferrite, which may be "molded" into the correct shape, and which is formed of a composition having superior magnetic properties including high initial permeability, high saturation flux density, and a high enough Curie point to insure stability at normal operating temperatures.

FIGURE 9 illustrates the final assembly with coils **56** and **57** and non-magnetic side plates **58** and **59** applied to the assembly of yoke **50** pole piece assembly **61** of FIGURE 7. The side plates facilitate mounting of the assembly and serve to strengthen and reinforce the gap unit in its mounting with the yoke **50**. In many cases, the side plates **58** and **59** may be omitted and surfaces **46** and **47** and **50***a* and **50***b* glued in place.

It will be apparent that many modifications and varia-

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tions may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. The method of making pole piece assemblies for magnetic heads which comprises polishing to a flat planar configuration surfaces of a pair of blocks of ferrite material, placing said surfaces in confronting relation with a magnetic gap therebetween, securing said blocks to each other by means of a non-magnetic bonding material which is substantially rigidly connected with said blocks and which extends continuously therebetween over substantially the entire area of said confronting surfaces, subdividing the blocks into units each including a portion of one block and a portion of the other block directly across said gap therefrom with a portion of the bonding material being rigidly connected with said portions and extending continuously therebetween to rigidly maintain the dimension of the portion of said magnetic gap therebetween, and shaping said units to provide completed pole piece assemblies for magnetic heads.

2. The method of making pole piece assemblies for magnetic heads which comprises placing a pair of flat planar surfaces of a pair of single crystal ferrite blocks in confronting relation with a magnetic gap therebetween, securing said blocks to each other by means of a non-magnetic bonding material which is substantially rigidly connected with said blocks and which extends continuously therebetween over substantially the entire area of said confronting surfaces, and subdividing the blocks into units each including a portion of one block and a portion of the other block directly across said gap therefrom with a portion of the bonding material being rigidly connected with said portions and extending continuously therebetween to rigidly maintain the dimension of the portion of said magnetic gap therebetween.

3. The method of making pole piece assemblies for magnetic heads which comprises placing a pair of single crystal ferrite blocks with flat planar surfaces thereof in confronting relation and with directions of easy magnetization of said blocks extending at right angles to the interface between said blocks and extending in a direction at right angles to the first direction, securing said blocks to each other by means of a non-magnetic bonding material which is substantially rigidly connected with said blocks and which extends continuously therebetween over substantially the entire area of said confronting surfaces, and subdividing the blocks along orthogonal planes at right angles to said interface to provide pole piece assemblies having directions of easy magnetization corresponding to the directions of flux linkage of the respective pole piece assemblies.

4. The method of making a magnetic head which comprises polishing surfaces of a pair of blocks of single crystal ferrite to substantially optical flatness, placing said surfaces in confronting relation, securing said surfaces to each other by means of a coating on said surfaces over substantially the entire area thereof of a non-magnetic bonding material providing a substantially rigid connection between said surfaces over substantially the entire area of said confronting surfaces, subdividing the blocks into pole piece assemblies each including a portion of one block and a portion of the other block directly opposite thereto with a portion of the non-magnetic bonding material being rigidly connected with said portions and maintaining the confronting surfaces of said portions in fixed relationship, and assembling said pole piece assemblies into completed magnetic heads.

5. The method of making pole assemblies for magnetic heads which comprises polishing an extended surface of each of a pair of members of ferrite magnetic material to a smooth planar condition, placing the extended surfaces of the members in confronting parallel relation with non-magnetic adhesive material directly therebetween, pressing said extended surfaces toward each other with said adhesive material therebetween in a flowable condition



and allowing the adhesive to harden and adhere to at least substantially the entire area of said extended surfaces, and cutting said members along planes transverse to said extended surfaces to provide a plurality of pole piece assemblies each including portions of the respective members with said portions of the respective members having confronting parallel faces formed by portions of the respective extended surfaces of said members and with said portions of the respective extended surfaces of said members being separated by a gap formed by the portion of the non-magnetic adhesive material therebetween and with said portion of said adhesive material therebetween adhering to the entire area of said portions of said respective extended surfaces of said members and securing said portions of said respective extended surfaces of said members together in spaced parallel relation to each other.

6. The method of making magnetic heads which comprises polishing an extended surface of each of a pair of ferrite members to a smooth planar condition, placing the extended surfaces of the ferrite members in confronting parallel relation with non-magnetic gap spacer material between said extended surfaces and with adhesive material in a flowable condition located to bond the gap spacer material and the extended surfaces together upon hardening thereof, bonding said extended surfaces of said ferrite members and said non-magnetic gap spacer material together with said extended surfaces of said ferrite members in said confronting parallel relation by allowing said adhesive material to harden, with said non-magnetic gap spacer material substantially filling the space between said extended surfaces, cutting said ferrite members along planes transverse to said extended surfaces to provide a plurality of pole piece assemblies each including portions of the respective ferrite members and said portions of the respective ferrite members having confronting parallel faces formed by portions of the respective extended surfaces of said ferrite members with said portions of the respective extended surfaces of said ferrite members being separated by a portion of said non-magnetic gap spacer material, and assembling the pole piece assemblies with other head components to provide completed magnetic heads.

7. The method of making a magnetic head which comprises polishing an extended surface of each of a pair of ferrite members to a smooth planar condition, placing the extended surfaces of the members in confronting parallel relation, bonding a non-magnetic gap spacer material to the respective extended surfaces of the members thereby to bond the extended surfaces of said ferrite members to each other, with said non-magnetic gap spacer material substantially filling the space between said extended surfaces, cutting said ferrite members along orthogonal planes transverse to said extended surfaces to provide a plurality of pole piece assemblies formed by portions of the respective members with said portions of the respective members having confronting parallel faces formed by portions of the respective extended surfaces of said ferrite members and with said portions of the respective extended surfaces of said ferrite members being separated by a portion of the non-magnetic gap spacer material, and assembling each pole piece assembly with a yoke of magnetic material having windings thereon to form a completed magnetic head.

8. The method of making a magnetic head which comprises polishing an extended area surface of each of a pair of ferrite members to a smooth flat planar condition, placing the extended area surfaces of the ferrite members in confronting parallel relation with a non-magnetic gap spacer material therebetween, bonding the gap spacer material and the surfaces together, severing the members along planes disposed transversely to said confronting parallel extended area surfaces to form a plurality of individual pole piece assemblies each formed from portions of the respective ferrite members and said portions of the respective ferrite members having parallel con-

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fronting polar faces separated by a portion of said non-magnetic gap spacer material, securing said pole piece assemblies to a common reinforcing mass of material, shaping the pole piece assemblies into final configuration, and assembling the pole piece assemblies with other head components to provide completed magnetic heads.

9. The method of making a magnetic head which comprises polishing an extended area surface of each of a pair of ferrite members of magnetic material to a smooth flat planar condition, placing the extended area surfaces of the members in confronting parallel relation with a non-magnetic gap spacer material therebetween, bonding the gap spacer material and the surfaces together, severing the members along orthogonal planes disposed transversely to said confronting parallel extended area surfaces to form a plurality of individual pole piece assemblies each formed from portions of the respective ferrite members and said portions of the respective ferrite members having parallel confronting polar faces separated by a portion of said non-magnetic gap spacer material, securing said pole piece assemblies to a common reinforcing mass of material, shaping the pole piece assemblies into final configuration, and assembling each of the pole piece assemblies with a yoke of magnetic material having windings thereon to form a magnetic head.

10. The method of making a magnetic head which comprises polishing an extended area surface of each of a pair of members of ferrite magnetic material to a smooth flat planar condition, placing the extended area surfaces of the members in confronting parallel relation with a non-magnetic gap spacer material therebetween, securing said ferrite members to a common reinforcing mass of material, severing the members along generally orthogonal planes disposed transversely to said confronting parallel extended area surfaces to form a plurality of individual pole piece assemblies each formed from portions of the respective ferrite members and said portions of the respective ferrite members having parallel confronting polar faces separated by a portion of the non-magnetic gap spacer material and said portions of the respective ferrite members being held in fixed relation by a portion of said common reinforcing mass which is secured to one side of said portions of said ferrite member and spans the magnetic gap therebetween, removing material from said portions of the respective ferrite members at the opposite side thereof from said one side to form notches in said portions of the respective ferrite members which reduce the extent of said parallel confronting polar faces of said portions of the respective ferrite members, filling said notches with a non-magnetic reinforcing material to secure said portions of the respective ferrite members in rigid relationship, removing said portion of said common reinforcing mass of material at said one side of said portions of the respective ferrite members and shaping tape receiving surfaces at said one side of said portions of the respective ferrite members and assembling each pole piece assembly with a yoke of magnetic material having windings thereon to form a magnetic head.

11. The method of making magnetic heads which comprises placing an extended planar surface of one block of ferrite material with the surface having an area approximating one-eighth square inch in spaced confronting parallel relation to an extended planar surface of another block of ferrite material with the surface of the other block having an area confronting said area of the surface of said one block approximating one-eighth square inch and with non-magnetic adhesive material directly between the confronting areas of said surfaces, pressing said extended planar surfaces toward each other with said adhesive material therebetween in a flowable condition and allowing the adhesive material to harden and adhere to



at least substantially the entire extent of the confronting areas of said surfaces and substantially completely fill the space between said confronting areas of said surfaces with said surfaces rigidly held in confronting parallel relation to each other by said adhesive material therebetween, cutting said blocks along orthogonal planes disposed transversely to said extended planar surfaces to form a plurality of individual pole piece assemblies each comprising a pair of pole pieces formed from portions of the respective blocks of ferrite material and having parallel confronting polar faces rigidly held in spaced confronting relation by a portion of said adhesive material, and assembling the pole piece assemblies with other head components to provide completed magnetic heads.

12. The method of making magnetic heads which comprises selecting a pair of blocks of ferrite magnetic material having edge dimensions approximating one-quarter inch by one-half inch by one-half inch, placing extended planar surfaces of said pair of blocks of ferrite magnetic material in confronting parallel relation with said planar surfaces having area approximating one-eighth square inch and with the interface between said surfaces forming a magnetic gap and with the dimension of each block in the direction at right angles to said interface approximating one-half inch, bonding said surfaces to each other over substantially the entire area of said interface, cutting said blocks along planes at right angles to the interface of the blocks to form a plurality of pole piece assemblies each formed from rectilinear portions of the respective blocks and said rectilinear portions of the respective blocks having parallel confronting polar faces bonded together over substantially the entire area thereof, and assembling the pole piece assemblies with other head components to provide completed magnetic heads.

13. The method of making magnetic heads which comprises selecting a pair of blocks of ferrite magnetic material having edge dimensions approximating one-quarter inch by one-half inch by one-half inch, placing extended planar surfaces of said pair of blocks of single crystal ferrite material in confronting parallel relation with a separation between said surfaces less than 5 microns and with the interface between said surfaces forming a magnetic gap, bonding said surfaces to each other over substantially the entire area of said interface, cutting said blocks along orthogonal planes at right angles to the interface to form a plurality of pole piece assemblies each comprising a pair of pole pieces formed from portions of the respective blocks of single crystal ferrite material and having parallel confronting polar faces bonded to each other over substantially the entire area thereof, and assembling the pole piece assemblies with yokes of magnetic material having windings thereon to form completed magnetic heads.


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R 400

*Philips Res. Repts* **15**, 342-367, 1960

# DURABLE HIGH-RESOLUTION FERRITE TRANSDUCER HEADS EMPLOYING BONDING GLASS SPACERS

by S. DUINKER

621.395.625.3

**Summary**

The magnetic and mechanical properties of a very dense, homogeneous and fine-grained ferrite are discussed with reference to its application as a material for making transducer heads for magnetic recording and reproducing for which it was specially developed as a substitute for laminated metallic alloys. The technique of producing transducer gaps by preparing ultra-thin (i.e., from less than one micron onwards), well-bonding and stress-free glass layers between polished ferrite surfaces is described, and the excellent qualities of such gaps as regards their optically and magnetically measured length and their wear-resistance are discussed. Several novel single- and multiple-track head constructions are outlined which, compared to existing assembling methods, are characterized by reduced production costs. This is because the expensive mechanical operations (polishing and gap preparation) can be confined to the most vital parts of the head (i.e., the frontal part containing the gap) and can be done for a large number of heads simultaneously in a prefabrication stage.

**Résumé**

On discute les propriétés magnétiques et mécaniques d'une ferrite très dense, homogène et à petits grains spécialement développée pour être utilisée dans la fabrication des têtes transductrices pour l'enregistrement et la reproduction magnétiques. La technique de fabrication de l'entrefer des têtes consiste à insérer entre des surfaces polies de ferrite des couches de verre extrêmement minces (à partir d'un micron), bien adherentes et sans tensions mécaniques. De tels entrefers présentent des qualités optiques et des propriétés magnétiques excellentes ainsi qu'une grande résistance à l'usure. Plusieurs nouvelles constructions de têtes à pistes simples et multiples sont exposées, ces constructions étant caractérisées par une fabrication moins coûteuse que les méthodes d'assemblage usuelles. Cela provient du fait que les opérations mécaniques coûteuses (le polissage et la préparation de l'entrefer) peuvent être reservées aux parties de la tete les plus vitales (c'est-à-d. à la partie frontale qui contient l'entrefer) et que ces opérations peuvent être effectuées simultanément pour un grand nombre de têtes dans un stade de préfabrication.

**Zusammenfassung**

Die magnetischen und mechanischen Eigenschaften eines sehr dichten, homogenen und feinkörnigen Ferrits werden besprochen, und zwar hinsichtlich seiner Anwendung als Herstellungsmaterial für Transduzentköpfe für die magnetische Aufzeichnung und Wiedergabe, für welche es zur Ersetzung der lamellierten metallischen Legeringen speziell entwickelt worden ist. Die Herstellungstechnik für Kopfspalte durch das Einbringen sehr dünner, gut haftender und spannungsfreier Glasschichten zwischen polierte Ferritflächen wird beschrieben und die Präzision solcher Spalte bezüglich der optisch und der magnetisch gemessenen Länge und der Verschleißfestigkeit wird besprochen.

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Weiterhin werden verschiedene neue Ein- und Mehrspurenkopfkonstruktionen auseinandergesetzt, welche im Vergleich zu gebräuchlichen Zusammensetzungsmethoden weniger Produktionskosten erfordern. Dies wird dadurch erreicht, daß die teueren mechanischen Operationen (Polieren und Spaltherstellung) auf die wichtigsten Teile des Kopfes (d.h. das den Spalt enthaltende Vorderstück) beschränkt werden und überdies für eine große Anzahl von Köpfen gleichzeitig in einer Vorbearbeitungsstufe geschehen.

## 1. Introduction

It is common knowledge that transducer heads for recording on, and reproducing from, magnetic tapes, and which are usually of the general shape schematically represented in fig. 1, are subjected to wear which continually changes their characteristics as to sensitivity and resolving power. Eventually, depending on head design and operating conditions, replacement of the heads is necessary when the dimensions of the gap (which are the essential parameters determining the quality of the recording and the reproduction process) have become too much affected by abrasion.

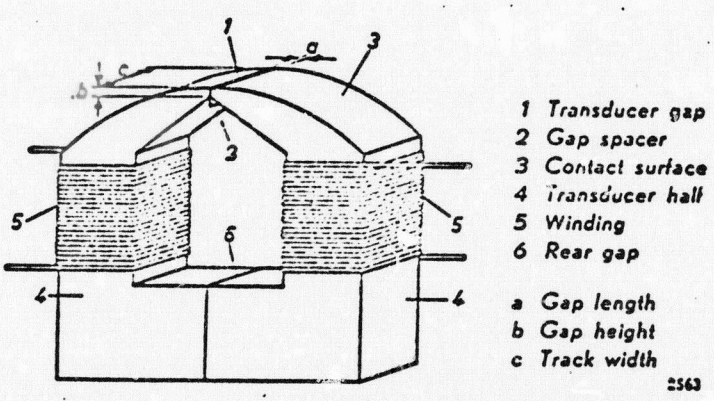


Fig. 1. General shape of ordinary type of transducer head.

The application of ferrites in magnetic transducer heads as a substitute for laminated metallic alloys, in order to improve wear resistance and to reduce the losses, seems to have been suggested originally by Snoek, the inventor of the modern ferrites, in 1946 [1]). The first patent applications were filed in 19[illegible] almost simultaneously but independently by Westmijze and Kleis [2]) and by Bergmann [3]). Since that time, however, ferrites have been used almost exclusively in wide-gap erase heads (in which sensitivity and resolving power are of minor importance) and in heads for pulse applications where the head is spaced from the medium carrying the information (and where head wear does not occur at all), as for instance in magnetic-drum-storage systems for computers [4]).

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In heads that have to be used in contact with the medium and for which consequently head wear is an important factor, especially for continuous-duty equipment, a number of reasons have prevented ferrites from coming into use. The main obstacles, as the following brief historical review shows, seem to have been that commerically available ferrites usually possess a coarse-grained structure, implying a poor gap definition, and that they are rather hard and brittle, leading to difficulties in fabrication.

Herr [5]) tested several ferrites and obtained gap edges with irregularites of about 10 microns after machining the gap faces with Arkansas hard stone. Youngquist and Wetzel initially reported [6]) experiments with a ferrite head having an effective gap width of 12·5 microns and a satisfactory lifetime. Their paper, however, was withdrawn [7]) because the tentative conclusions put forth therein could not be confirmed in subsequent tests. Apparently using a better technique, Cruel [8]) realized an effective total gap length of 14 microns and obtained an improvement in the total operating life of the head of at least a factor of 10 as compared to metallic heads. Using a corrected gap-length formula, Schmidbauer [9]) experimentally determined the roughness of the gap surfaces and the contact surface of ferrite heads. He found irregularities due to inclusions, voids and pores of the order of from 3 to 6 microns.

Concluding that it was obviously impossible to prepare short, durable and well-defined gaps from the ferrites then available, Kornei [10]) designed a new type of high resolution transducer head in which the contact side and the gap area was formed by two thin sheets of a metallic magnetic material named Alfenol. This material was first suggested for use in heads by Lufcy and Heath[11]) on account of its high wear-resistance and its low losses. The Alfenol pole shoes in this head, spaced at a distance of about 1 micron by evaporated silicon-monoxide layers, were attached to a ferrite body to provide a low-loss flux path.

The brittleness of ferrites is not only a drawback in the fabrication stage of the head but also brings about an erosion effect during operation. This effect completely ruins the gap edges and thus reduces the lifetime of the head, despite the hardness of the material. Merry [12]) suggested filling the gap of metallic heads with a bonding agent such as Araldite, and it was thought initially that the same technique might prevent gap erosion from occurring in ferrite heads. It turned out, however, that no significant improvement could be obtained in this way, owing to the inferior wearing properties of the Araldite. Chynoweth[13]), applying a glazing technique to prevent gap erosion, as was suggested earlier by Cruel [8]), reported that although new ferrite heads showed resolutions comparable to those of metallic heads, the wearing properties remained deficient.

Initially unaware of Chynoweth's experiments, we have studied along somewhat similar lines the problems connected with head wear and gap erosion since 1953. Ultimately, these investigations have yielded very durable high-

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resolution ferrite transducer heads with bonding glass spacers and of rather revolutionary design. To arrive at these results it was necessary to develop a dense, fine-grained ferrite material and a matched glass, and to improve the technique of polishing the ferrite. By melting-in, as a spacer material, glass of carefully selected properties gap lengths could be obtained of less than one micron and onwards, without observable irregularities and with a wear resistance considerably better than that of metallic heads.

It is the purpose of the present paper to report on these investigations and to discuss the construction of heads using the glass-spacer technique for various fields of application.

## 2. Properties of ferrite head material

To judge the usefulness of ferrites in magnetic heads we shall briefly discuss their most pertinent physical properties which are of both magnetic and mechanical nature.

The data presented refer to the nickel-zinc ferrite that was specially developed for our purpose by Mr Stuijts and which has been given the code designation Ferroxcube (Fxc, for short) IV A2. In this material a compromise was adopted between the different requirements in the various fields of application so that it could successfully be applied for audio as well as for video recording and reproducing transducer heads. Investigations into materials with optimum properties for a particular rather than a more universal field of application are still in progress.

### 2.1. *Magnetic properties*

The most important magnetic properties of the Fxc IV A2 material are collected in table I. For comparison, the data are confronted with those pertaining to alloys which up till now have usually been applied in, or recommended for, head construction.

The most striking difference found in the table between the properties of Fxc IV A2 and the alloy materials is exhibited by the specific resistance. The existence of eddy currents in a laminated metallic core results in a loss of power and in an uneven distribution of the flux across the section. The latter effect reduces the effective permeability progressively as the frequency is increased. Ferroxcube IV A2 on the other hand has such a high resistivity, together with a moderate value for the dielectric constant, that at frequencies well within the megacycle region eddy currents are reduced to a minimum, allowing the material to be used in solid form.

The absence of eddy currents implies that there occurs no deterioration of the field in the direct neighbourhood of the gap. This is of predominant importance for the performance and the efficiency of the head, especially in recording heads, which are used at higher flux levels than reproducing heads are. For reproduc-

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cing heads the low losses imply a low value for the intrinsic head noise, which is extremely important in connection with the signal-to-noise ratio. The low conductivity may sometimes give rise to static charges which cause dust and oxide collection on the head, but this has proved not to be a serious handicap in practice.

It appears from table I that the initial and the maximum permeability of Fxc IV A2 are both considerably smaller than those of the alloy materials. Particularly for reproducing heads, but to a lesser extent also for recording heads, this is generally undesirable. It should be stressed, however, that the values presented for the alloys are valid only for well-annealed, laminated toroidal samples that are completely free from stresses and strains. In practice, if laminated heads are constructed from these materials, much lower values are realized. Unfortunately, this is again especially the case at those parts to the head which determine the head performance (i.e., the gap area and the contact side), owing to the machining processes which have to be carried out there. For the completed head it is impossible to restore the original properties by an annealing process. In practice, therefore, the high values quoted in table I for the alloys are illusory whereas the more realistic values would differ considerably less from those of Fxc IV A2 which is hardly sensitive to mechanical stresses. We shall return to this aspect later on in the discussion (cf. sect. 3.2).

Another aspect that should be borne in mind is that the permeability values presented in table I for the alloys refer to measurements at 50 c/s. The permeability decreases at higher frequencies much quicker for the alloys than it does for Fxc IV A2, for which the real and the imaginary part of the (series) complex initial permeability, i.e., $\mu'$ and $\mu''$, respectively, are plotted as a function of frequency in fig. 2. From these data we deduce that ferrite heads will have a constant self-inductance together with a high and constant $Q$ in a wide range of frequencies. One obtains a still better insight into the usefulness of ferrites in the high-frequency range by considering the loss factor $(\tan \delta)/\mu'$ which is also plotted in fig. 2 for Fxc IV A2. Similar data are not available for the alloys but the superiority of Fxc IV A2 is perhaps convincingly demonstrated by making the following comparison:

For a metallic head with a lamination thickness of 0·1 mm (the smallest commercially available thickness which can reasonably be handled for head construction), an effective permeability equal to that of Fxc IV A2 and a specific resistance corresponding to the Ni-Fe alloys, the loss factor $(\tan \delta)/\mu'$ is equal to 1 at a frequency somewhat below 0·1 Mc/s. This limiting frequency decreases with increasing permeability. For Fxc IV A2 on the other hand we see from fig. 2 that $(\tan \delta)/\mu'$ is smaller than $10^{-3}$ for frequencies up to 4 Mc/s.

From this example we learn that the low-frequency data for the coercive force and the saturation induction, which are also given in table I and from which one deduces for Fxc IV A2 a higher low-frequency hysteresis loss than for the

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**Table I**

**Physical properties of transducer head materials**

| material / property | Fxc IV A2 (1) | Mumetal (2) | Permalloy 4-79 (2)(3) | Vacodur 16 (2)(4) | dimension |
|---|---|---|---|---|---|
| composition | NiO 17·5<br>ZnO 32·5<br>$Fe_2O_3$ 50·0 | Ni 77<br>Cu 5<br>Cr 2 | Ni 79<br>Mo 4 | Al 16 | for ferrite: mol %<br>for alloys: % by weight, balance Fe |
| initial permeability | 0·85 | 30 | 25 | 5(a)<br>7(b) | $\times 10^3$ at 0·4 A/m<br>5 m Oe |
| maximum permeability | 2·5 | 70 | 60 | 30(a)<br>60(b) | $\times 10^3$ |
| coercive force | 32 | 2·4 | 3·2 | 2(a)<br>4·8(b) | A/m = 0·0125 Oe |
| saturation induction | 0·39 | 0·8 | 0·9 | 0·9 | $Wb/m^2 - 10^4$ G |
| specific resistance | $>10^8$ | 0·50 | 0·55 | 1·45 | $\mu\Omega m = \Omega mm^2/m$ |
| Curie temperature | 125 | 400 | 460 | 350 | °C |
| relative hardness | 600 | 118 | 132 | 220-280 (a)<br>350 (b) | Vickers HV 5 |

(1) tentative data

(2) data supplied by Vacuumschmelze AG, Hanau a.M., Germany

(3) known in U.S.A. under other trade names such as: Hy Mu 80, Mo-Permalloy, Permalloy C

(4) this material is similar to the Alfenol material described in ref. [11]

(a) cold-rolled

(b) hot-rolled

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alloys, should not be taken for judging the high-frequency losses.

However, the rather low saturation induction of the ferrite, which is unimportant for reproducing heads, is disadvantageous for recording heads in which saturation effects at the gap edges could give rise to field deterioration, particularly for small gap lengths. This is mainly due to the fact that the smaller the gap length is, the smaller will be the useful leakage flux; the latter, being the actual recording field, has to have some specific strength determined by the coercivity of the tape, which is usually in the order of 120 kA/m (≈ 250 Oe).

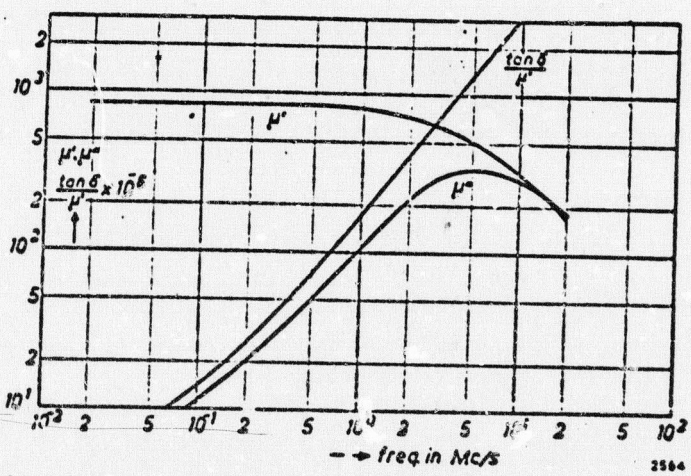


Fig. 2. Real part ($\mu'$) and imaginary part ($\mu''$) of initial permeability, together with loss factor $(\tan \delta)/\mu'$, plotted as a function of frequency for Ferroxcube IV A2. Note the differences in vertical scale.

It is undesirable to reduce the latter too much since this would increase the demagnetization of the recorded signal for small wavelengths, resulting in a poor resolution [14]). Furthermore, irreversible demagnetization leading to distortion is then liable to occur [15]). Under normal operating conditions, experiments with Fxc IV A2 recording heads have not given evidence of saturation effects so that the low saturation value has proved not to be a serious handicap.

The Curie temperature of Fxc IV A2 is also appreciably lower than that of the alloy materials. As a consequence of this the temperature coefficient $\Delta\mu/\mu^2\Delta T$ is higher, viz., $6.10^{-6}$ as compared to $0{\cdot}15.10^{-6}$ for Mu-metal. This, however, is no longer a serious problem since for applications where a low temperature coefficient is required the ferrite could easily be made almost temperature independent in a wide range of temperatures by substituting a small percentage of cobalt [16]).

In conclusion it can be stated that the properties discussed indicate that, from a magnetic point of view, no serious disadvantages obstruct the use of ferrites

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in transducer heads for low-frequency applications, whereas especially for the high-frequency applications the properties of ferrites are definitely superior to those of the metallic alloy materials.

### 2.2. *Mechanical properties*

In ordinary ferrite applications the magnetic properties are of primary importance, whilst the mechanical properties as such are hardly of any interest. Therefore, it is not surprising that it turns out to be necessary to modify these mechanical properties in order to meet the requirements for durable transducer heads. The following mechanical properties, which are characteristic of ferrites in general, are of particular interest to the construction of transducer heads.

(1) *Granularity*. This is an intrinsic property of ferrites since they are manufactured by sintering a milled and prefired raw material using some organic binder. With a coarse-grained structure well-defined sharp gap edges, and hence transducer heads with well-defined gaps and a high resolving power, cannot be obtained, and for this reason considerable attention was given to the development of a material with a uniform fine-grained structure. In Fxc IV A2 the grain-size varies from 10 to 30 microns as can be seen in the photo-micrograph I which shows a polished surface of this material after etching.

(2) *Inhomogeneity*. To a great extent this is also due to the sintering process which, for instance as a result of imperfect mixing, may give rise to the presence of voids, inclusions and pores. These not only affect the gap edges in heads, but also make it impossible to obtain perfectly polished surfaces. Holes in the contact surface of a head (i.e., the surface along which the tape travels) act as a site from which erosion begins. This erosion, being a cumulative effect, is very harmful to the head performance as soon as it attacks the gap edges. In developing Fxc IV A2, therefore, the aim was to obtain, in addition to a fine-grained texture, a porosity as low as practicable with the pores as small as possible and uniformly dispersed. For Fxc IV A2 the porosity amounts to 3·5%, of the roentgen density which is 5·33, the average size of the pores being less than 2 microns.

(3) *Hardness*. This is a desired property inasmuch as it is a necessary condition for good resistance to wear. On the other hand, the hardness may present difficulties in the various stages of fabrication, viz., cutting, grinding, lapping and polishing, unless special measures are adopted. It will be clear that the hardness depends on the structure of the material and that the development towards a uniform, fine-granular and dense material will lead to a harder product. Table I shows the relative hardness of Fxc IV A2 to be definitely superior to that of the alloy materials.

(4) *Strength*. This is another property of importance to the wearing qualities of the material. In this respect it is not the tensile strength as such which is important (and which for ferrites, being of a ceramic nature, is inferior to that

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of metallic materials), but rather the mechanical strength with which the individual magnetic grains are cemented together. This is particularly true of the polished contact surface of a head where, if a particle gets loose, a site of erosion is created while the particle itself might set free other particles.

(5) *Brittleness.* This property is more or less a consequence of the foregoing properties. Added to the hardness it leads to easy chipping during fabrication which is, of course, undesirable in head construction. Chipping can be avoided by using an appropriate coolant in all the stages of machining, viz., cutting with a rotating diamond wheel, grinding on a cast-iron backing plate using silicon carbide of successively finer grades as an abrasive and, finally, lapping and polishing on a tin lap using diamond powder.

In developing the polishing technique for Fxc IV A2 a remarkable and extremely useful effect was found. The porosity, which is about 3·5% for the bulk of the material, was decreased enormously at the polished surface to a value of about 0·2%, yielding an ultra-thin, extremely hard and wear-resistant skin. The photo-micrographs II*a* and *b* show in the same magnification as for photograph I the finish obtained after lapping and after polishing, respectively. Since in transducer heads in particular those parts are polished which are subjected to wear and erosion (viz., the contact surface and the gap faces) this is a highly desirable effect. The effect has presumably to be attributed to a re-sintering process of abraded ferrite particles at the high temperatures that occur on a microscopic scale during polishing, since experimental evidence of the occurrence of plastic flow has been found.

After having determined the appropriate method of machining, several experimental transducer heads were built. The first specimens had the general shape represented in fig. 1. Although it was possible to produce well-polished surfaces and sharp gap edges, the heads constructed from this material, which were provided with different kinds of metal spacers, still suffered from gap erosion after some time of operation at medium tape speeds. It seemed impossible to equal the lifetime of laminated metallic heads in this way.

The main reason for this negative result is thought to lie in the fact that in such a construction the two halves of the head necessarily have to be pressed rather tightly together in order to keep the spacer between them in position. Consequently, strong forces are exerted at the gap faces and edges so that chipping, initiating the erosion process, occurs.

### 3. Bonding-glass-spacer technique

The difficulties reported at the end of sec. 2.2. can be eliminated entirely by having the gap edges supported by some material that bonds well to the gap faces without creating an appreciable tension either in the bonding material or in the ferrite. Preferably, this material should completely replace the spacer

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and should have mechanical properties very similar to those of the ferrite itself. It has been possible to select some glasses satisfying these requirements.

The bonding-glass-spacer technique consists in the sandwiching of a shim of glass, of a thickness exceeding the gap length ultimately desired, between the polished mating gap faces of the two halves of the head (or of the portion of the head that will contain the gap) which have first been given the required shape. Then this structure is heated up to a temperature within the softening range of the glass and the two halves are pressed together. In view of the viscosity of the glass only a very small amount of it is pressed out of the gap if the latter is not longer than about 10 microns. This permits a predetermined value of the gap length to be adjusted rather accurately by taking glass shims of an appropriate thickness and by taking into account the pressure, the area of the glass film and the viscosity at the pressing temperature. The shortest gap length realized in our experiments was about 0·5 micron. For gap lengths exceeding 10 microns mica spacers are necessary to ensure a predetermined value. After relieving the pressure the assembly is cooled down very slowly.

By machining the contact surface of the head a given gap height can be obtained. It appears in the grinding and polishing processes that a perfectly regular and straight gap can be obtained only if the glass bonds well to the ferrite and the linear expansion coefficients of glass and ferrite are matched as well as possible, not only for room temperature but in the entire range from the softening temperature of the glass down to room temperature. In fig. 3 the thermal expansion coefficients of Fxc IV A2 and of the glass used in our experiments are shown. It is seen that the glass begins to soften at about 500 °C, but the structure is heated up to a considerably higher temperature, e.g. 850 °C, in order to obtain a good adherence of the glass to the ferrite.

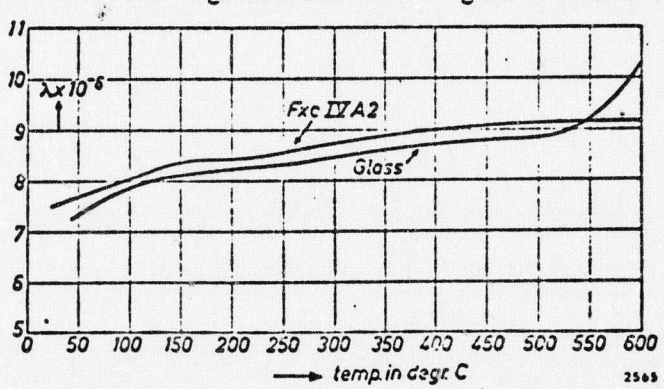


Fig. 3. Thermal expansion coefficients of Ferroxcube IV A2 and of the glass used for gaps as a function of temperature.

The requirement of a good adherence will be clear immediately for it means that the ferrite grains at the gap edges, particularly those of which a consider-

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able portion has been removed by the earlier machining operations and which might therefore easily crumble off, are held tightly in their places.

The requirement of equal expansion coefficients necessitated repeated experiments with different kinds of glass. For different expansion coefficients for glass and ferrite, the glass layer will be subjected to appreciable stresses when cooling down, although mechanically reasonably strong joints are still possible. However, in the subsequent stages of machining the glass will then get cracked as a result of the cutting action of the abrasive which relieves these stresses. The cracks penetrate deeply downwards into the glass layer and constitute an irremovable site for gap erosion. We think that Chynoweth's [13]) unsatisfactory results were mainly due to the expansion coefficients of his glazes and enamels and the ferrite not being matched.

One may expect that if the glass is properly selected so that no damage occurs to the gap or to the contact surface during the various machining operations, the wear resistance of the finished head under normal operating conditions in conjunction with a magnetic tape will be satisfactory too. This is because, in fact, the latter process from a mechanical point of view is simply a polishing process, using as an abrasive material the magnetic material from the tape, i.e., single crystals of $\gamma$-$Fe_2O_3$, which as regards hardness and abrasive action is closely related to the abrasive material known as crocus, i.e. $\alpha$-$Fe_2O_3$.

### 3.1. *Optically observed gap definition*

The optical quality of the gaps obtainable in applying the bonding-glass-spacer technique is clearly demonstrated by the photo-micrographs III, IV and V. Figures III and IV correspond to high-resolution audio heads with gap lengths of about 7·5 and 1·8 microns, respectively. Figure V shows the gap of a video head with a gap length of about 0·7 micron. The last two photographs, which were taken in an oil-immersion microscope, are not quite sharp since the resolving power of the microscope was somewhat exceeded (a gap length of 0·7 micron corresponds to the wavelength of red light which implies that it is impossible to determine accurately the exact length of gaps of this order of magnitude by optical means).

Optically judged the glass gaps are highly superior to the gaps obtainable in metallic heads, which are always somewhat irregular as a result of the laminated structure and the smearing out of both the spacer and the head material during lapping. Irregularities in the gap contribute to lower signal-to-noise ratio, especially when separate heads, with in general incongruent gap irregularities, are used for recording and for reproducing.

### 3.2. *Actual magnetic gap definition*

The actual behaviour of a head, particularly a reproducing head, is not governed in the first place by the mechanical quality of the gap as optically observed

but rather by the effective gap length which determines the resolving power, i.e., the shortest wavelength that can be reproduced. In this respect, too, ferrite heads with bonding glass spacers are superior to metallic heads. This is not only because of the low value for the noise associated with the losses in the ferrite material.

We already noted in sect. 2.1 that the permeability of laminated nickel-iron alloys appreciably diminishes as a result of the assembling operation. This is not too serious since the permeability still retains a sufficiently high value. However, what is much more serious, owing to the lapping of the gap faces and of the contact surface, is that these surfaces become work-hardened, i.e., a working skin results which has a depth of about 1·5 microns and in which the permeability gradually drops to a very low value so that the magnetic properties almost vanish. The aluminium-iron alloy seems to be slightly better in this respect, but it is still reported [11]) to possess a working skin of from 0·3 to 0·5 micron.

This effect, which cannot be eliminated by an annealing process for a completed head, sets a limit to the usefulness of metallic heads if we try to realize a high resolving power, for it means that in principle gap lengths (and hence reproduced wavelengths) smaller than about 3 microns are impossible to achieve. Furthermore, the non-magnetic skin at the contact surface implies that, even if the tape runs in contact with the head (a contact which in practice always is imperfect, even for ideally polished heads, due to the inevitable surface roughness of tapes which is of the order of 0·5 micron) there is physically always a spacing between head and tape which is detrimental to the output of a reproducing head [17]). To a lesser extent these factors are also disadvantageous for recording heads.

For metallic heads with non-laminated metallic pole shoes (e.g., of Alfenol) we may expect on account of the afore-mentioned factors that the effective gap is only somewhat larger than the optically observed one, and with about the same irregularities. For laminated heads, however, the situation is worse since for each lamination the thickness of the working skin, reckoned from the middle towards the non-magnetic, insulating inter-lamination layers, will increase. These heads therefore, even if their optically observed gap definition is rather satisfactory, will have an effective gap of a herring-bone structure of which the periodicity is determined by the pitch of the laminations. For high-resolution heads with gap lengths of the order of a few microns these irregularities will be at least of the same order of magnitude.

On the other hand, for heads made of Fxc IV A2 no such working skin could be observed. The optically estimated gap length very accurately corresponds to the effective gap length which can be determined experimentally by recording a range of frequencies at various tape speeds and looking for the first zero in the response [18]). The shortest gap length that can be determined in this way is

about two microns, which is otherwise about the shortest wavelength to be recorded on tapes for which the mean length of the iron-oxide particles is of the order of 1 micron.

We deduce from these measurements that apparently the working skin at the gap faces, if any initially existed, is completely nullified during the high-temperature procedure of melting the glass spacer material, which is in effect some sort of annealing process in so far as the ferrite is concerned. Furthermore, no evidence has been found that the magnetic properties of the extremely dense skin at the contact side of the head, resulting from the polishing process discussed in sect. 2.2, are different from those of the bulk of the material. From the foregoing discussion it is evident that a better signal-to-noise ratio may be expected for ferrite reproducing heads than for metallic heads.

### 3.3. *Wear-resistance quality of glass gaps*

Transducer heads which are subjected to wear have to be replaced from time to time. However, what is perhaps a more serious matter, especially in continuous-duty professional equipment, during the wearing away of the head its characteristics are continually changing.

For recording heads a diminution of the gap height means that the high-frequency biasing field, which is superimposed on the signal to be recorded in order to secure linearity, shifts to a lower value. Further, the head sensitivity (i.e., the strength of the low-frequency signal necessary for full magnetization over the entire depth of the magnetic layer at a given frequency and a given bias) increases, and the pre-emphasis to be applied to the signal for correction of the overall frequency characteristic also increases. If, at the same time, the wear affects the gap definition as regards gap width and sharpness of gap edges, then the resolving power of the head also decreases since the latter is largely determined by the gradient of the stray flux in front of the gap and this is larger the shorter and better-defined the gap is.

For reproducing heads the sensitivity (i.e., the level of the output voltage resulting from a signal of some specific wavelength recorded on a reference tape which possesses a specific surface flux density) becomes larger at decreasing gap heights. Since the gap length must be small compared to the shortest wavelength to be reproduced, the crumbling or the rounding-off of the gap edges detrimentally affects the resolving power of the head.

These factors imply that a frequent readjustment of the electrical equipment is necessary in order to maintain a certain standard of quality for the reproduced signals. It needs hardly to be said that an improvement of the durability of transducer heads is of great importance. The problem of head wear, however, is extremely complicated since a very large number of factors is involved, such as: surface smoothness and hardness of head and tape material, contact pressure, wrap angle and tape speed. These factors may differ considerably from

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one application or situation to another, and it is therefore not permissible t extrapolate data on head wear obtained at high tape speeds to lower tape speeds. This means that extremely time-consuming experiments are required to obtain exact data on the life of heads for each particular field of applicatio Hence, it is difficult to make general statements about the durability of transducer heads.

However, from experience concerning the wear resistance of a variety o ferrite heads containing bonding glass spacers in various applications durin a period of several years, we feel justified in stating that these heads are highly superior to metallic heads. A few examples will be mentioned.

In one experiment a Mu-metal head and a ferrite head, both having a gap length of 7 microns and similar characteristics, were tested simultaneously in a standard professional equipment for 500 hours at a tape speed of 0·38 m/s (15 in./s). After this period the metal head was completely worn down, whereas the ferrite head showed no electrically measurable evidence of wear.

In another experiment, concerning video recording, heads with extremely narrow track width (150 microns) were tested at a relative tape speed of about 30 m/s and at still higher rewind speeds. After 50 hours (corresponding to the passing of approximately 5500 km of tape) the output of the heads started to fall off, not as a result of gap erosion but because of the track width becoming narrower, due to the crumbling off of the sides of the head. These were initially embedded in a casting resin but gradually became unsupported when this resin was wearing away. A much improved lifetime of the head can be expected by adequately supporting these sides of the head. This can be done by dipping the frontal part of the head (which contains the glass gap of the correct length and which already has been polished down to the required curvature, gap height and track width) in molten enamel, after which so much of the enamel is removed by grinding, lapping and polishing that the original contact surface of the head reappears. To secure that the dimensions of the gap are not destroyed by the dipping operation, the enamel should have its softening range starting well below (e.g., 200 °C) that of the glass that fills the gap. To avoid stresses and cracks it is, just as for the glass in the gap, imperative for the enamel too to have its expansion coefficient matched to that of the ferrite in the entire range down to room temperature. The photo-micrograph VI gives a detailed picture of such an embedded head (not a video head) with a gap length of about 12 microns.

As a tentative and conservative conclusion we estimate from these and other experiments that the life of ferrite heads with bonding glass spacers for professional applications at medium tape speeds (i.e., 0·19 to 0·38 m/s) will be at least several thousand hours, equivalent to the passing of several thousands of kilometers of tape. For the improved design of video head at extremely high relative tape speeds we reckon with the handling of a total length of tape of at

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least 20 000 km, which compares favourably with the figures quoted for other types of video head with Alfenol 16 or HyMu 80 pole-tips [10], [19]). For audio entertainment equipment with its low tape speed of 9·5 cm/s and less, and its less stringent electrical requirements, we expect the life of the head to be practically indefinitely long.

From the foregoing it should not be concluded that ferrite heads will have a long life under all operating conditions. There are circumstances that have a detrimental effect on ferrites but for which metallic alloys are perhaps much less sensitive. In discussing the life expectation of heads in various fields or application, we tacitly assumed the heads to be subjected to "normal" operating conditions in which care is taken that circumstances that are particularly harmful to ferrite heads are avoided as much as possible. Unfavourable conditions are met in the operation of heads in a closed-loop system, where the same joint in the tape is always hitting the contact surface in the same manner and where hard particles mounted in the tape always scratch the surface at the same places so that, in the long run, grains can be bumped out or deep scratches can be caused. Another example in which ferrite heads might give less satisfactory results is in the operation in conjunction with sound tracks on movie films which are much stiffer than the ordinary magnetic tapes and where hence a much higher contact pressure is necessary in order to obtain the necessary wrap angle. Once the polished contact surface is damaged by scratching or by chipping, nothing can prevent it from wearing down very quickly.

### 4. Head constructions with bonding glass spacers

From what has been said about the technique of preparing bonding glass spacers it will be clear that the method of constructing laminated metallic transducer heads must be completely abandoned for ferrite heads containing glass-filled gaps. There is even no reason to maintain the usual general shape which, to a great extent, is dictated by the production techniques for thin laminations. Ferrites, on the other hand, can be easily moulded or cut into shapes which are more adapted to the purpose of constructing glass-spacered heads. The photograph VII shows various prototype ferrite transducer heads with their component parts which were constructed in the laboratory for testing purposes in different fields of application.

The most essential difference compared with metallic heads is, of course, the prefabrication of the frontal part of the ferrite head containing the glass gap. This feature offers at the same time some very attractive possibilities for simplifying the technique of transducer-head construction, such as the cutting out of a larger sample of individual frontal parts, or of entire heads, with absolutely equal gap lengths and which, possibly, are already polished down to a given gap height and the desired radius. Some idea of these possibilities

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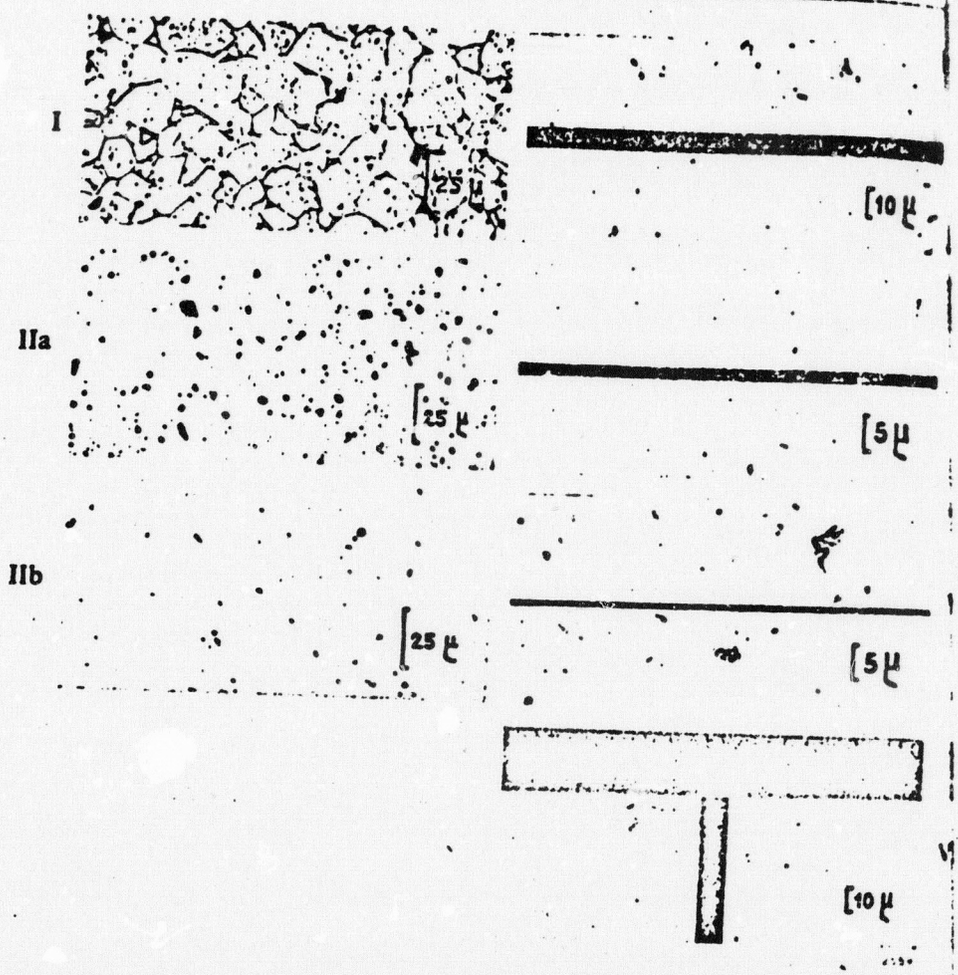


Photograph I. Photo-micrograph showing a polished surface of Ferroxcube IV A2 after etching.

Photograph II. Photo-micrographs showing a polished surface of Ferroxcube IV A2: (*a*) after lapping; (*b*) after polishing.

Photograph III. Photo-micrograph of an audio recording head with a gap length of 7·5 microns.

Photograph IV. Photo-micrograph of a high-resolution audio reproducing head with a gap length of about 1·8 microns.

Photograph V. Photo-micrograph of a high-resolution video head with a gap length of about 0·7 microns.

Photograph VI. Photo-micrograph of a detail of a head which is enameled at the sides for protection, and containing a gap with a length of about 12 microns.

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Photograph VII. Variety of prototype ferrite transducer heads and component parts for different fields of application.

is given by several samples shown in the photograph. A more detailed outline is given below.

The simplest type of head consists of a closed magnetic circuit interrupted by two glass-filled gaps, namely, the useful gap in the front and a second one in the rear. For high-resolution reproducing heads the reluctance of the rear gap is made negligibly small, in particular smaller than the butt joint obtainable in metallic heads, by giving the ferrite there a sufficiently large cross-section area, while the gap length itself has the same small effective value as has the front gap. These closed-type heads have the disadvantage of having to be wound by a toroidal winding machine or even by hand if the aperture is too small. This type of head is therefore used mainly for special applications such as the recording and reproduction of video signals where the ratio between the reluctance of the rear part and that of the front gap should be made as small as possible; a condition which is difficult to fulfil when the front gap is extremely short (2 microns, say) whereas the reduction of the gap height is limited by mechanical reasons to a value of about 100 microns.

If we want to avoid the difficulties encountered in closed-type heads we can make the head to consist of two separate parts, viz., the frontal part containing the useful gap and a U-shaped yoke carrying the windings; the two parts are intimately fixed to each other by means of flatly ground mating surfaces. Some examples of such a construction can be seen in the photograph of fig. 9. The heads thus constructed possess a magnetic circuit with three interruptions, namely, the useful gap and two butt joints. The effect of the latter, as to the increase of the reluctance of the rear part in concurrence with that of the useful gap, can easily be kept to a minimum by choosing the cross-section large enough and by making the mating surfaces smooth and flat enough. The fact that ferrites have no observable working skin, as we discussed earlier, is very favourable in this respect and has withheld us in many cases from using laminated metallic rear yokes despite their higher permeability.

In order to amplify some typical features encountered in the construction of ferrite heads with bonding glass spacers we will give a brief general outline of the construction of two categories of transducer head which were developed in the laboratory and which have proved to possess promising properties. These types of head bear some resemblance to heads provided with replaceable metallic pole-tip caps which are described in the literature [20]). However, these differ from the ferrite heads in one rather fundamental aspect, namely, in that the fabrication of the pole-tip has to be performed for each head individually in the expensive orthodox manner with loose spacers, without there being any possibility of doing this for a large number of heads simultaneously. It will be clear that the examples to be given do not exhaust the possibilities offered by the prefabrication of glass gaps. A variety of other designs based on the same general principles are of course possible and have in fact also been tried out.

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4.1. *Construction of high-quality transducer heads*

For several professional applications, such as in studio equipment, for data-recording and for video-recording, transducer heads of supreme quality are necessary. We will not repeat here what has been written earlier about gap quality, lifetime and high-frequency performance of glass-spacered heads, but merely indicate how heads in which these favourable properties are combined can be constructed on a production scale in an economical way.

In fig. 4*a* the prefabrication of the frontal parts of a number of heads is shown. The ferrite blocks I and II, each being profiled to the desired shape by cutting or by moulding, are cemented together with glass layers *g* of the desired thickness constituting the gaps for series of future heads. If moulded pieces of ferrite are employed, the mating gap faces have to be ground rather thoroughly before polishing so as to remove the entire sintering skin, which has unfavourable magnetic and mechanical qualitites.

It will be noticed that the ferrite blocks differ in shape in the direct neighbourhood of the gaps. There are three different reasons for this. In the first place, it allows a predetermined gap-height *h'* to be obtained over the entire length of the sample, irrespective of the possible shifting of the two blocks with respect to each other as might occur under pressure at the high temperature required to melt the glass, an effect that is difficult to correct. Secondly, by applying some additional glass in the spaces *b*, the bond between the two pieces, which otherwise would have to be secured by the gap material alone, is reinforced. Thirdly, the extending parts a of block II may serve as a plane of reference in a later stage of the construction, if we want to construct multiple-track heads with aligned gaps.

When the ferrite blocks are cemented together, the structure can be partitioned into pieces of a width *w* corresponding to the desired track width as shown by the dashed lines. In the drawing one frontal part has been omitted.

A cross-sectional view of a completed head is shown in fig. 4*b*. The magnetic circuit is closed by attaching a U-shaped core 2 carrying the windings 3 to the frontal part 1 containing the glass gap *g*, by means of a spring 4. After potting the whole structure in a casting resin 5, the contact side of the head is polished down to a given gap height *h* and to the desired curvature. These latter machining operations could alternatively be carried out for a number of heads simultaneously in a stage prior to the partitioning of the block into individual frontal pieces, but then, of course, we do not have the possibility of controlling the gap height electrically through a head-inductance measurement while polishing.

This construction can be applied for heads with a track width of say 6·4 mm (i.e., 1/4 inch) or more. For narrower tracks difficulties arise in clamping both parts of the head together, while at the same time the reluctance of the two butt

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joints increases to too high a value. To avoid this, the construction according to figure 4*c* can be used. Here, the two parts of the head, 1 and 2, are attached sideways to each other and kept in position by two clips 4.

An alternative method for obtaining frontal parts is sketched in fig. 4*d*. Instead of using profiled pieces of ferrite, two rather arbitrarily shaped blocks,

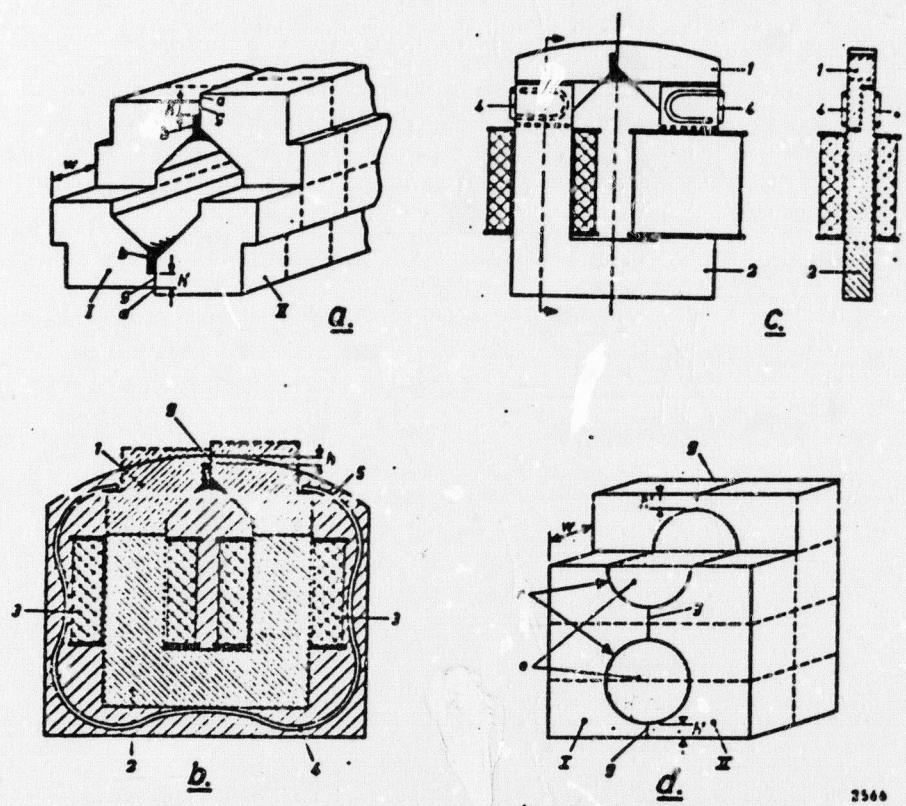


**Fig. 4.** Various stages in the construction of high-quality transducer heads for professional applications: (*a*) prefabrication of frontal parts containing the glass gap *g* for a series of heads simultaneously; (*b*) cross-sectional view of completed head after potting; (*c*) alternative method of combining frontal piece and U-shaped core in the case of narrow track width; (*d*) alternative method for obtaining frontal parts; after preparation of the glass gap *g*, cylindrical holes *r* are drilled which are filled with enamel *e*.

I and II, which are only lapped at the future gap faces, are cemented together with glass that constitutes the gap *g*. In this structure, cylindrical holes *r* are drilled (e.g., with a diamond crown borer) so that their axes are lying in the plane of the glass gap and are situated apart over a distance of about twice the gap height *h'*. Next, these holes are filled with a well-bonding enamel *e*, having an expansion coefficient matched to that of the ferrite and having its softening range starting sufficiently below that of the glass in the gap (cf. the discussion in sect. 3.3 about

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the construction of narrow-track video heads with reinforced enameled sides). Finally, individual frontal parts of the desired track width *w* are cut out, as is indicated by the dashes lines.

Although two subsequent heating operations are necessary (viz., for the glass gap and for the enamel, respectively), this method for obtaining frontal parts offers some advantages over the previous one, namely, lower overall machining costs (no profiling of individual blocks), easier gap preparation (no precise adjustment of blocks with respect to each other), greater mechanical strength (the glass gap no longer secures the bond between the halves of a frontal part alone), and closer tolerances for the ultimate gap height *h*.

### 4.2. *Mass production of audio transducer heads*

For audio transducer heads intended for use in entertainment apparatus, production costs must be kept to a minimum. Since the tape speeds usually are low in these applications less stringent requirements apply to the shape of the contact side of the head as long-wavelength contour effects are not to be feared [18]). Furthermore, the bandwidth to be handled is also appreciably smaller than for professional heads. These circumstances permit cheap, mass-produced audio heads of good quality to be constructed.

In fig. 5 various stages in the construction of the head are illustrated. Figure 5*a* shows the prefabrication of the glass gap *g* of the desired thickness between two ferrite blocks I and II. Just like the construction of fig. 4*d*, the only requirement for these blocks is that they should be lapped at the surfaces that will form the gap; no other machining operations (e.g., profiling) are necessary, and therefore they can be made very cheaply.

Once the gap is made, the structure is cut into slices of a thickness *t* of 0·5 to 1 mm and of a width corresponding to the track width desired for the head, as is indicated by the dashed lines. Each slice, of which a large number can be obtained from a single stack, serves as the pole piece 1 (fig. 5*b*) that has to be attached to a U-shaped yoke 2 (fig. 5*c*) in order to complete an individual head (fig. 5*d*). It will be clear that this procedure of prefabricating gaps of the required length *l* for a large number of heads is much more economical than the construction methods used for metallic heads, where the gap length has to be adjusted for each head individually.

The U-shaped yoke 2 has an opening of width *c*; this is made large enough to permit the passing of the coils 3 which have a winding thickness of 5. The yoke can be made of metallic laminations or of ferrite material moulded to shape. The mating surfaces *f* of the yoke and the pole piece must, of course, be ground sufficiently flat in order to keep the reluctance of the butt joint to a low value. Note that the positioning of the pole piece 1 on yoke 2 is not very critical; the gap *g* should lie somewhere in the middle beyond the opening *c*. The pole piece is kept in position by the casting resin 4 which also fills the space of opening *c*.

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Finally, the potted head is polished at the contact side to the required gap height $h$ and the desired curvature. In the present construction larger radii have to be tolerated for the latter than in the case of profiled pole pieces as discussed in sect. 4.1 and for which the radius should not exceed a critical value if long-wavelength effects are to be avoided. Sometimes it may be necessary to reduce

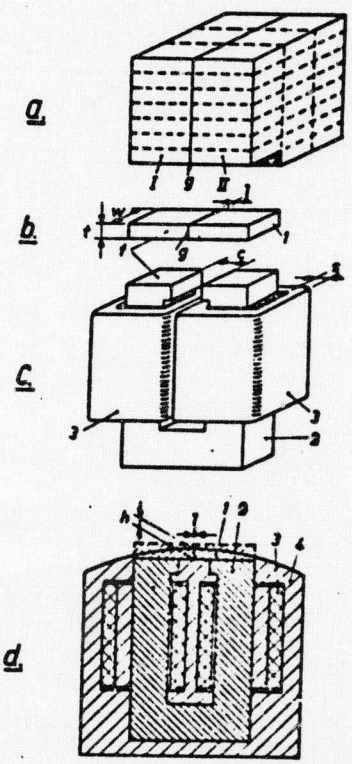


Fig. 5. Various stages in the mass production of audio heads: (*a*) prefabrication of the glass gap between two ferrite blocks; (*b*) individual pole piece containing the prefabricated gap cut out from the larger block; (*c*) U-shaped yoke carrying the windings; (*d*) cross-sectional view of the assembled head after potting.

the gap height $h$ by cutting a groove at the bottom side of the pole piece according to the plane of the gap (not shown). In this case we obtain again a more or less profiled pole piece, the difference with the construction of sect. 4.1 being that the profiling now is done after the construction of the gap so that difficulties in the positioning of the parts are avoided.

Essentially the same technique can be used to make more complicated types of transducer head, such as double-track heads which are required for stereo reproduction, and double-gap heads which have to be used for extremely low tape speeds (when the conflicting requirements as to the gap lengths holding for

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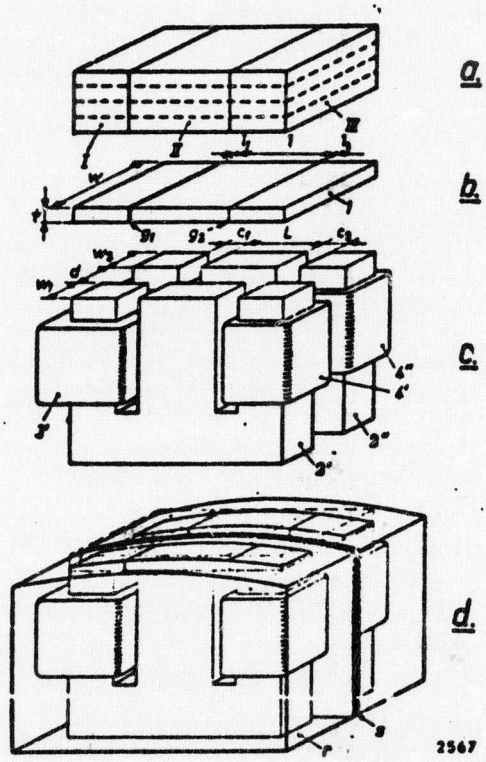


Fig. 6. Various stages in the production of double-track, dual-gap audio head combinations: (*a*) preparation of dual gaps of unequal length; (*b*) individual pole piece containing two prefabricated gaps obtained from the larger stack; (*c*) two M-shaped yokes, each carrying a recording winding and a reproducing winding; (*d*) view of the completed head after potting and after separating both tracks.

recording and reproducing heads can no longer be reconciled in a single head). An example of a double-track, double-gap head combination is illustrated in fig. 6.

The pole pieces 1 are now obtained from a stack of three, instead of two, ferrite blocks: I, II and III. Block II is lapped at the two future gap faces which have to be mutually plane-parallel at a given distance *l*. The two glass-filled gaps, $g_1$ and $g_2$, are made simultaneously and have widths of, e.g., 20 and 2 microns, corresponding to recording and reproducing heads, respectively.

The M-shaped yokes 2′ and 2″ each carry a recording winding (3′ and 3″) and a reproducing winding (4′ and 4″). The two yokes are positioned apart at the desired inter-track distance *d* by clamping them at the shorter ends in a jig (not shown). This jig at the same time serves as the potting mould. Before the potting, pole piece 1 is provisionally cemented together with yokes 2′ and 2″. Then the inter-track part of the material of the pole piece is removed so as to separate the two dual heads, and electric and magnetic shields *s* are placed be-

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tween them. After potting the structure in a casting resin the contact side of the combined heads is polished.

A somewhat simpler alternative method, but with which slightly more pole-piece material is wasted, is that in which the pole piece at the yoke side is provided with a groove of a width corresponding to the inter-track distance and of a depth a little larger than the gap height ultimately desired. The pole-piece is attached to the combination of yokes and shields and the structure is subsequently potted. The remaining inter-track pole-piece material is automatically removed during polishing. In this method slightly thicker pole-pieces have to be employed to secure the necessary strength for handling the pole piece after making the groove.

From the outline of the procedures just described it will be clear that the heads will have perfectly aligned gaps which, moreover, are accurately parallel and have exactly the same length two by two. The method of construction can, of course, be extended to head combinations with more than two parallel tracks.

Recently, new stereo-recording techniques have been developed with which it is possible to record frequency ranges up to 15 k c in two or three narrow (1 mm) tracks on a tape of a width of 3·2 mm (1/8 in.) running at the extremely low speed of 4·75 cm/s (1⅞ in./s). The multiple-track heads required for the reproduction of such recording should have gap lengths of the order of 1 micron. With the head-construction technique just described these rather strong requirements could be realized conveniently in several prototypes. It is hardly possible, if at all, to obtain similar accurate results by constructing heads according to the loose-spacer technique which is customary for metallic heads nowadays.

## 5. Conclusion

In conclusion it may be said that the development of a very homogeneous, fine-grained and dense nickel-zinc ferrite of favourable magnetic properties in combination with a technique of preparing ultra-thin, well-bonding and stress-free glass layers has made possible the construction of magnetic transducer heads of superior quality. In comparison with laminated metallic heads, ferrite heads with bonding glass spacers are in the advantage on the following items:

(*i*) *wear resistance*, owing to the hardness and dense texture of the material, to the smoothness of the contact surface obtainable by polishing and to the tightness of the bond between glass-spacer material and the ferrite;

(*ii*) *optically observed gap definition*, which is determined by the regularity, the straightness and the mutual parallelism of the gap edges resulting from the excellent polishing properties of the ferrite;

(*iii*) *actual magnetic gap definition*, which is due to the uniform field distribu-

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tion in and around the gap owing to the absence of mutually insulated laminations;

(*iv*) *resolving power*, which is related to the shortness of the effective gap length that can be realized and which for ferrite heads is determined entirely by the thickness of the glass film owing to the absence of a working skin with inferior magnetic properties;

(*v*) *sensitivity*, resulting from the smoothness of the contact surface and the absence of a working skin so that an intimate head-to-tape contact implies a close magnetic contact, and further from the small gap height that can be chosen on account of the high wear resistance;

(*vi*) *electrical performance*, in particular signal-to-noise ratio, due to the superior electric and magnetic properties of ferrites at the highest frequencies of interest for magnetic recording;

(*vii*) *design properties*, resulting from the fact that ferrites unlike metallic laminations can be given almost any particular shape by cutting or by moulding;

(*viii*) *production cost*, on account of the fact that the expensive mechanical operations (polishing and gap preparation) are exclusively confined to the most vital part of the head (i.e., the frontal part containing the gap) and, moreover, can be done for a large number of heads simultaneously in a prefabrication stage;

(*ix*) *maintenance*, due to the extremely high wear resistance which means that head replacement is hardly necessary and that the adjustment of the electrical equipment (which is necessary if heads have continuously changing properties resulting from wear) can be made once and for all.

**Acknowledgement**

The author is indebted to Mr J. Bos who was responsible for all the mechanical work connected with the various head constructions and whose superior craftmanship has helped to solve many mechanical difficulties in the early stages of the development. Thanks are also due to his colleague, Mr A. L. Stuyts, for the development of the suitable ferrite material. The stimulating interest and helpful suggestions of Dr W. K. Westmijze and Messrs G. Bakos and N. Wittenberg are gratefully acknowledged.

*Eindhoven, August 1959*

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June 8, 1965 M. B. VILENSKY 3,188,400

FERRITE COATING

Filed Jan. 9, 1961

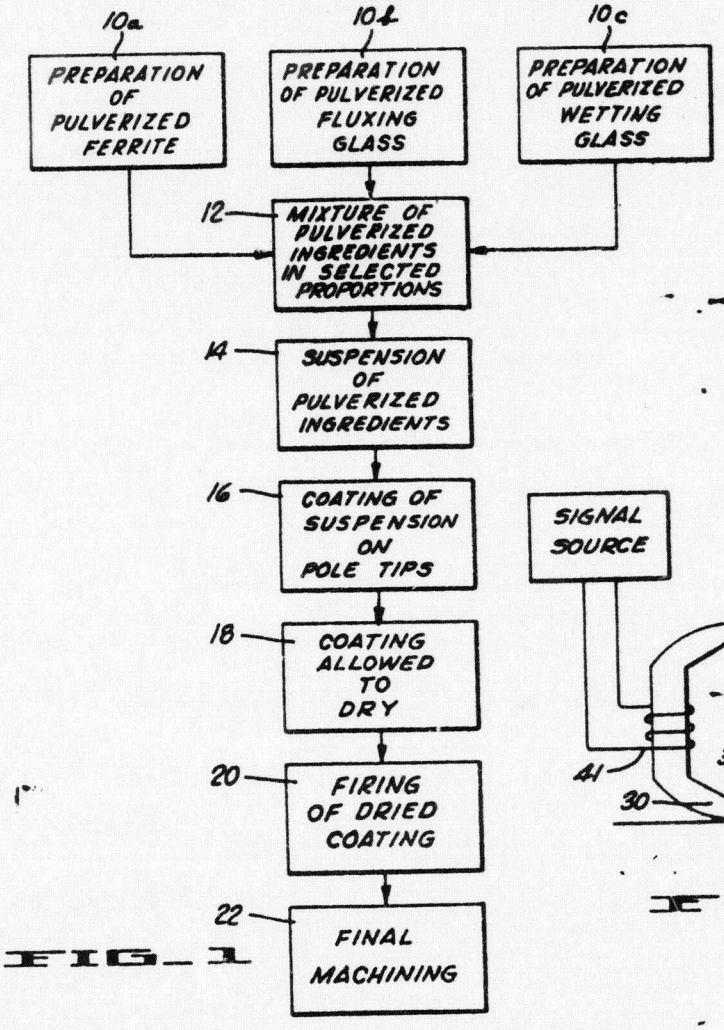


FIG_1

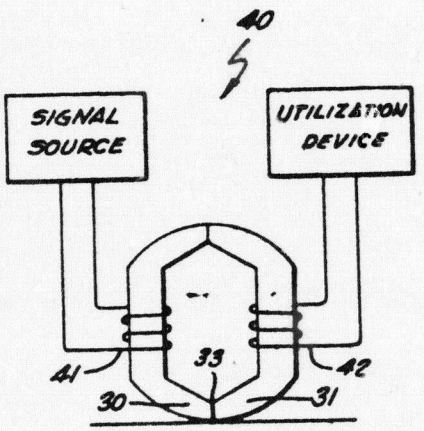


FIG_3

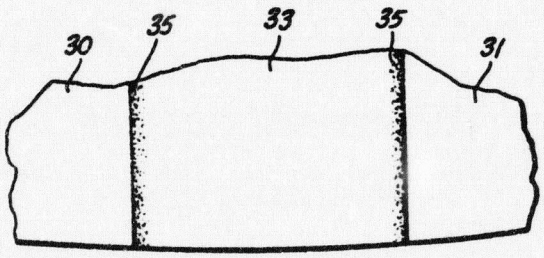


FIG_2

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United States Patent Office

3,188,400
Patented June 8, 1965

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3,188,400

# FERRITE COATING

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Filed Jan. 9, 1961, Ser. No. 81,479
5 Claims. (Cl. 179—100.2)

This invention relates to ceramic seals and joinders, and particularly to methods and structures for providing a spacer element between the pole tips of a ferrite magnetic head assembly.

While many different techniques are now known and used for joining ceramics to metals, and for providing ceramic to metal seals, fully satisfactory ceramic to ceramic seals and joinders have not heretofore been provided for many applications. Difficulties have been encountered, because an applied ceramic may have an adverse effect upon the operative properties of the base material to which it is applied.

A useful illustration of the foregoing situation is found in the art of magnetic recording wherein ceramic magnetic materials are often used in transducer assemblies for the recording and reproduction of signals. Magnetic head assemblies employ a high reluctance, or substantially nonmagnetic, gap or spacer element in the vicinity of a magnetic record surface. In recording, a magnetic field is established between the pole tips on either side of the nonmagnetic spacer element. The presence of the spacer element causes a fringing flux to pass through the adjacent magnetic record surface to leave a remanent magnetization pattern which is an accurate representation of the electrical signals being recorded. To reproduce these signals, the head assembly is moved relative to the record medium, with the pole tips and the spacer element passing in contact with, or very close to, the remanent magnetization fields that exit at the record surface. A changing magnetic field is thus established in the magnetic head assembly to induce currents in a coil and thereby generate signals that are representative of the initially recorded signals.

The above-described general type of construction for magnetic head assemblies is well known. It is also understood by those skilled in the art that the spacer element must be precisely defined, but physically stable. To this end, the magnetic head structure may be fabricated in two halves, and the pole tip elements that are to be on the opposite sides of the gap may then be separately shaped and machined. For final assembly of the two halves, suitable nonmagnetic gap forming elements, such as conductive metal or glass, are inserted between or applied to the exposed pole tips. The problems involved in obtaining suitable mechanical and magnetic properties in the final structure are, however, generally recognized to be appreciable. This is particularly true with respect to the magnetic ceramic materials, such as the various types of ferrites that are used in magnetic head designs.

Ferrite assemblies have especially good properties for a number of recording and reproducing applications. They operate sensitively over extremely wide frequency bands and at frequencies well into the megacycle per second region. For some applications, it is found to be preferable to fabricate the heads from a single ferrite crystals. Ferrite is a brittle material, however, particularly in single crystal form, and is often broken or chipped during fabrication or use.

The spacing between the pole tips of a head assembly may necessarily be extremely small, of the order of "microns" or less, for high resolution and high frequency capabilities. It will readily be understood that with such a spacing between the opposed pole tips it becomes very

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difficult to provide a spacer element, which can satisfy simultaneously the critical demands as to mechanical and magnetic properties that are placed upon it. The spacer should preferably provide a strong physical bond between the pole tips, or at least firmly adhere to each of the individual pole tips without irregularities or porosity, inasmuch as such defects adversely affect magnetic properties. The expansion coefficient of the gap spacer element should be close to that of the ferrite, inasmuch as wide differences cause internal stresses to be generated, which might result in chipping or cracking at the pole tips. Furthermore, the materials that form or define the gap must not chemically affect the ferrite in any way to alter the magnetic properties or the mechanical properties including the hardness and density, or the ferrite. With a vitreous spacer coated directly onto the ferrite, the melting point of the spacer material must be less than that of the ferrite.

Heretofore, spacer elements have been chosen for their nonmagnetic properties. Consistent with such approach, it has been thought that certain frequency and response limitations are inherently imposed by the dimensions of the gap between the pole tips. A very small gap has superior high frequency capabilities, for example, but also encompasses fewer flux lines at any instant in time. For this reason, gap size, in conventional head design, has been considered to limit output voltage to determinable magnitudes. A new form of construction, which overcomes these theoretical limitations, would obviously have wide utility and marked advantages.

It is therefore an object of the present invention to provide an improved ceramic to ceramic seal and joinder.

Another object of the present invention is to provide an improved method for sealing and joining a ceramic material.

A further object of the present invention is to provide a superior magnetic head assembly.

Yet another object of the present invention is to provide an improved method for fabricating a spacer element for a magnetic head assembly using a ferrite material.

Yet another object of the present invention is to provide an improved magnetic head assembly, having a firm and adherent spacer element between ferrite pole tips.

Another object of the present invention is to provide a magnetic head assembly having improved frequency and resolution characteristics.

Still another object of the present invention is to provide an improved method for coating a ferrite element with glass material in a manner that provides a physically stable structure having high strength and a minimum of irregularities.

A further object of the present invention is to provide improved structures and methods for fabricating magnetic head assemblies.

In methods and structures in accordance with the present invention, a ceramic seal or bond is provided for ceramic base materials by a composition that is so affixed that a microstructural transition layer is formed between the composition and the base ceramic. In a ferrite magnetic head assembly, for example, a precisely dimensioned and stable spacer element comprising a fluxing glass compound that includes ferrite particles in suspension is applied to each of the ferrite pole tips. A special compound including glass therein is utilized that is formed from a fluxing material, a wetting material, and a powdered ferrite. Each of the ingredients is prepared separately, and each of the ingredients is then pulverized to a degree of fineness in which each passes a selected, fine mesh. The ingredients are then mixed in a selected proportion, placed in suspension and the suspension is coated on the pole

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tips. After drying, the coating is fired at a temperature sufficient to vitrify the material. The resultant coating is firmly and mechanically united to the pole tips with a bond, free from porosities and other irregularities. The structure is such that at the firing temperature an interatomic exchange exists between the coating and the ferrite, resulting in the microstructural transition layer, which assures that both physical and magnetic properties will be as desired.

An important feature of magnetic head assemblies thus provided is a significant improvement in magnetic properties. The presence of pulverized ferrite in the spacer element somewhat reduces the reluctance of the spacer element. Instead of having an adverse effect upon operative capabilities, however, the change in permeability resulting is found to enhance signal strength and resolution characteristics.

A better understanding of the invention may be had by reference to the following description, taken in combination with the accompanying drawing, in which:

FIG. 1 is a block diagram representation of a process for providing a ceramic to ceramic seal in accordance with the invention;

FIG. 2 is an enlarged sectional view of a ceramic seal as employed in a magnetic head assembly provided in accordance with the present invention; and

FIG. 3 is a side view of a magnetic head assembly.

A practical example of a ceramic to ceramic seal and of a method in accordance with the present invention is provided by FIG. 1, which shows the steps that are employed in disposing a spacer element so as to join the pole tips of a ferrite magnetic head. As shown in FIG. 1, different ingredients are separately prepared for this purpose. It is known initially that the base ceramic material, here a magnetic ferrite ceramic, has a particular composition. In accordance with the invention, one of the initial steps is the preparation of a finely pulverized ferrite of like, or substantially like, composition to that of the base material. This is shown by step 10*a* in FIG. 1. Preferably, the pulverized ferrite is made sufficiently fine to pass a 325 mesh.

A fluxing inorganic complex is separately prepared, as shown in step 10*b* of FIG. 1. The primary requirements for this material are that it should be a suitable vitreous fluxing agent, and that it have a melting point below that of the ferrite which is to serve as the base structure. In a preferred example, the following molecular composition is employed:

| | |
|---|---|
| CaO | 0.20 |
| $K_2O$ | 0.10 |
| $Na_2O$ | 0.20 |
| $Li_2O_3$ | 0.50 |
| $Al_2O_3$ | 0.11 |
| $B_2O_3$ | 0.04 |
| $SiO_2$ | 1.45 |

A glass of this composition has a melting temperature between 1190° C. and 1225° C. The glass of this composition is obtained by melting corresponding oxide forming materials, such as carbonates, sulfates, and the like. The resulting product is pulverized and ball milled to a fineness corresponding to that of the ferrite. That is, the pulverized powder is reduced to a size at which it will pass a 325 mesh or smaller.

A third ingredient is also prepared, as shown in step 10*c* of FIGURE 1, this being an inorganic complex in the form of a glass having superior fluidity and wetting properties. These requirements are satisfied by lead type glasses having lead oxide contents not exceeding 60%. A preferred chemical composition for such a glass is as follows:

| | Percent |
|---|---|
| PbO | 50.0 |
| $Fe_2O_3$ | 20.0 |
| $SiO_2$ | 10.0 |
| ZnO | 5.0 |
| $B_2O_3$ | 15.0 |



As with the glass previously discussed, this glass may be prepared by the melting of oxide forming materials, followed by the pulverization of the resultant product to a fineness at which the particles pass a 325 mesh.

In the next step represented by a block 12 in FIG. 1, in accordance with the invention, each of the three prepared materials is thoroughly mixed with the others. As a practical example, it is preferred to use a mixture of the above ingredients in which the fluxing complex is approximately 35%, the wetting complex is approximately 40%, and the pulverized ferrite is approximately 25% by weight. It should be borne in mind that the mixing should be very thorough and for this purpose it is preferred to employ an agate or similar type mortar.

After the components are thoroughly mixed together, they may be suspended in a solution (step 14 in FIG. 1) so that they may be applied to the base ceramic. A preferred suspension is maintained in a solution of nitrocellulose prepared by dissolving dry nitrocellulose in diethyl carbonate and diethyl oxalate, in a proportion of 2.5 grams of dry nirtocellulose to 125 cc. of diethyl carbonate and 40 cc. of diethyl oxalate.

A suspension thus prepared may then be coated (step 16 in FIG. 1) onto the pole tips, which define the base ceramic for which a seal is desired. The coating may be applied with a brush or sprayed onto the base ceramic.

The coating then, step 18 in FIG. 1, is permitted to dry on the pole tips at room temperature. A selected thickness of coating may be built up on each pole piece, in order to control the dimensions of the resulting spacer.

Thereafter, as shown in step 20 in FIG. 1, the dried coating may be vitrified by firing at an elevated temperature in excess of the melting temperature of the glass constituents but below the temperature of the ferrite. Here, a temperature of 1000° C. to 1250° C., depending upon the type of ferrite to be coated, is maintained for a period of 10 to 15 minutes. To provide a unitary structure, the opposing pole tips may be held in parallel relation with the coatings in contact so that a single vitreous body results from the firing, and the pole pieces may be machined to final form. Where the pole pieces are not joined together by the spacer element during firing, a machining operation 22 may be used to control the thickness and plane of direction of the spacer element. Thus, on placing together the two halves of a pole piece assembly, the two facing surfaces which form the complete spacer element lie flush against each other, and the spacer element is coextensive with, but does not protrude beyond, the pole tips. Alternative methods of joining the pole tips with a precise spacing will readily suggest themselves to those skilled in the art.

A spacer element as thus provided for magnetic recording heads has a considerable number of material advantages over similar spacer elements heretofore available. It is physically stable, even though as ultimately machined it may be extremely thin (of the other of a few ten-thousandths of an inch or less). The thermal coefficient of expansion of the vitreous coating is substantially like that of the ferrite, so that few problems are presented by internally engendered stresses due to thermal expansion. The spacer element is also harder than the ferrite, so that the operative parts of a ferrite head are not unduly worn by contact with a record medium.

Further significant advantages derived from this type of ceramic structure may be appreciated by reference to the greatly magnified and somewhat simplified representation of FIG. 2. As shown in FIG. 2, the unitary structure is formed of a pair of ferrite pole tips 30, 31 with an intermediate spacer element 33. The drawing is not to scale, so that the relative sizes of the parts and layers shown are not to be considered as representative of actual

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dimensions. A magnetic head assembly 40 is shown in FIG. 3, this assembly 40 including coils 41, 42 coupled to an external signal source 43 and utilization device 44 and being disposed adjacent a record medium 45.

A microstructural transition layer 35 (shown shaded in FIGURE 2) is formed between the spacer 33 and each of the pole tips 30, 31. This transition layer 35 extends for only a relatively few microns in depth, but is uniform along the joining surfaces. The transition layer results from interatomic exchange between the ferrite and the coating at the elevated temperatures used in firing. It appears that the presence of finely divided ferrite in suspension considerably assists the formation of such layer.

The presence of the microstructural transition layer assures a good physical bond between the two ceramics. Furthermore, the structure is free from occluded gases, cracks, and other irregularities. In effect, a solid solution is formed with the ferrite at the transition layers. The entire structure is physically stable, has enhanced strength, and does not adversely affect the magnetic properties of the ferrite itself. Viewed in a slightly different sense, the ferrite becomes impregnated with glass throughout the entire microstructural transition layer, thereby providing a fine grain composition which has no pores or cracks but has instead a substantially homogeneous composition. For these reasons, the structure which is presented in contact with the magnetic tape is uniform but has high hardness, and therefore is not subject to wear which is otherwise encountered.

The increased strength and freedom from irregularities which are thus provided are particularly useful in ferrite head assemblies which employ single crystal ferrites.

It will also be recognized by those skilled in the art that ceramic seals in accordance with the invention may be used wherever it is desired to decrease the porosity of a ceramic or to increase its physical strength. Coatings applied in this manner provide a hermetic seal for the ferrite, thus preventing the escape of moisture and occluded gases.

Heretofore, magnetic head assemblies have utilized a low permeability gap, such as is provided by air or a nonmagnetic spacer element. The critical factor is not the gap itself, of course, but the strength and concentration of the magnetic field which penetrates the record medium. Here it is found that the variable permeability introduced by the limited amount of ferrite on the spacer element can be of material benefit in recording. The fringing field still exists, but is confined to the gap region. The configuration of the field is such, however, that virtually the same useful flux still exists.

The benefits of magnetic head assemblies in accordance with the invention are also realized in signal reproduction. Workers in the art have previously used the formula:

$$\text{Gap loss (in db)} = 20 \log \frac{\sin (\pi l/\lambda)}{\pi l/\lambda}$$

where: $l$=the effective gap length
$\lambda$=the wavelength of the recorded signal

This equation defines the recognized 6-db-peroctave increase in response of a magnetic head with frequency. Note that the "effective" gap length is usually greater than the theoretical with prior art heads. In heads according to the present invention, however, several advantages are concurrently obtained. The premeability of the ferrite actually decreases the effective gap length, thus lowering losses and bettering high frequency response. The firm bond and physical integrity of the spacer element permit a uniform and precisely dimensioned product to be fabricated and finished more readily. And the hardness of the spacer element, relative to the ferrite, means that the effective gap length does not decrease significantly with wear.

The advantages derived may also be viewed from the



aspect of the flux line distribution at the gap. Previously, with a very small gap, relatively few flux lines would be intercepted at any instant in time and only a low voltage would be produced. The presence of ferrite in the spacer element, however, effectively redistributes and concentrates the flux at the gap. More flux lines are thus intercepted at any instant and a higher output signal is produced.

Thus there have been described improved ceramic to ceramic seals, and methods of providing such seals, which provide a microstructural transition layer between the two ceramics. Spacer elements having excellent bonding and physical characteristics may be provided for magnetic head assemblies utilizing magnetic ceramic materials. The operative characteristics of magnetic head assemblies may be materially enhanced by utilizing spacer elements containing a proportion of pulverized ferrite in suspension.

What is claimed is:

1. A structure providing a physically stable spacer element between ferrite parts which includes a fired glass material containing ferrite particles corresponding to the ferrite parts and which defines microstructural transition layers at the joinder between the ferrite and spacer element, the transition layers being in the form of ferrite solid solutions.

2. A ceramic material for sealing together ferrite elements, including a fused body containing approximately 35% of a soda-lime type glass, approximately 40% of a lead type glass, with the remainder being a ferrite corresponding to the ferrite elements to be joined.

3. A magnetic head assembly including a pair of ferrite pole elements, and a vitreous spacer element joining the pole elements, the spacer element including a fluxing glass and having a selected proportion of ferrite particles in solution, there being a microstructural transition layer of a ferrite solid solution at the junction region between each of the pole elements and the spacer element.

4. A magnetic head assembly including a pair of ferrite pole elements and a vitreous spacer element firmly united to each of the pole elements, the vitreous spacer element including approximately 35% of a soda-lime fluxing glass, approximately 40% of a lead type wetting glass, and approximately 25% of a pulverized ferrite material corresponding to the material of the ferrite pole elements, the pulverized ferrite material being sufficiently fine to pass a 325 mesh, the melting temperature of the fluxing glass and wetting glass being below that of the ferrite material, and there being microstructural transition layers consisting of ferrite solid solutions at each junction surface between the spacer element and a ferrite pole element.

5. A magnetic transducer including a ferrite core defining pole tips separated by a selected gap, and a vitreous gap element coupling the pole tips and having in excess of 10% of pulverized ferrite in solution.


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Nov. 8, 1966 R. F. PFOST 3,283,396

MAGNETIC TRANSDUCER ASSEMBLY AND MANUFACTURE

Original Filed April 17, 1961 3 Sheets-Sheet 1

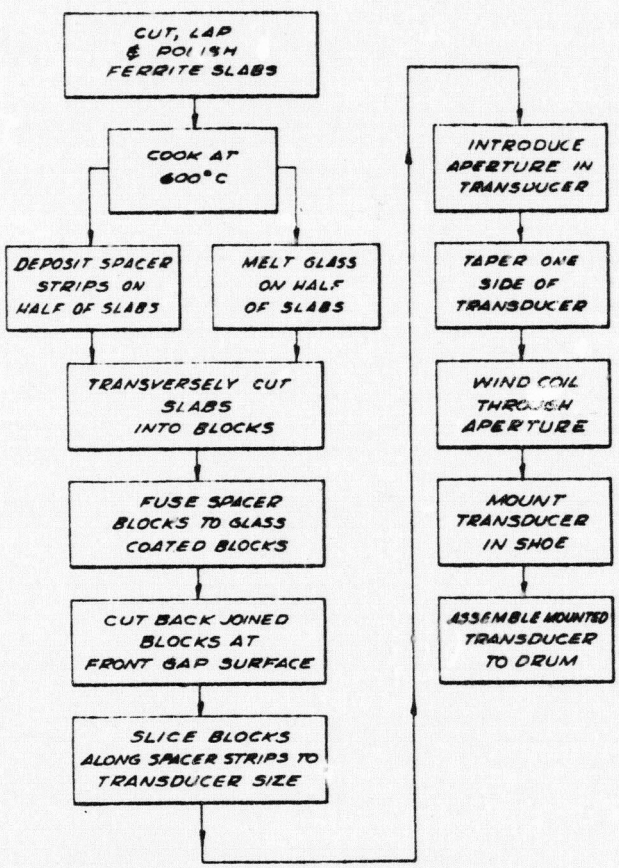


FIG. 1

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Nov. 8, 1966 R. F. PFOST 3,283,396

MAGNETIC TRANSDUCER ASSEMBLY AND MANUFACTURE

Original Filed April 17, 1961 5 Sheets-Sheet 2

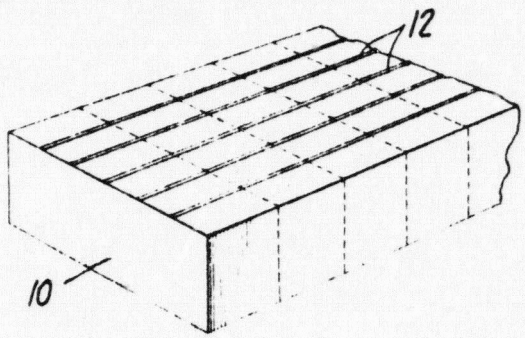


FIG. 1

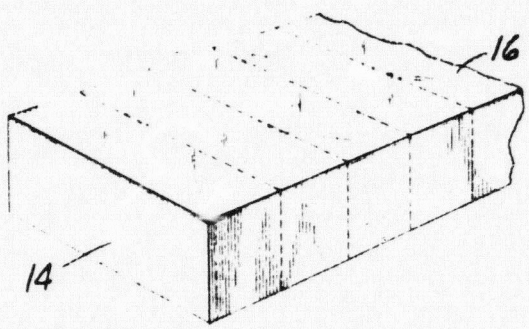


FIG. 2

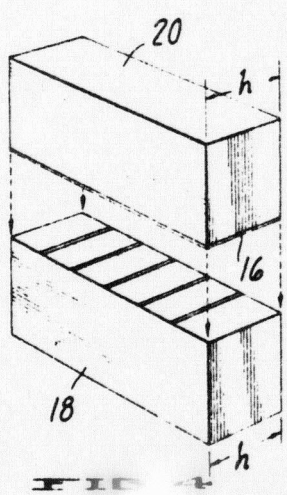


FIG. 4

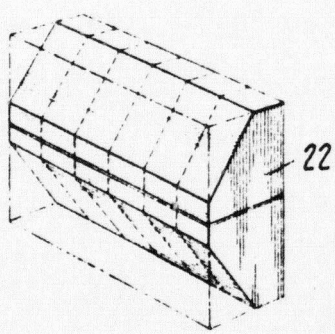


FIG. 5

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Original Filed April 17, 1961 5 Sheets-Sheet 3

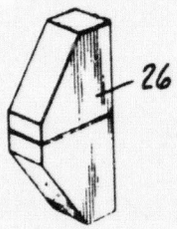


FIG_6

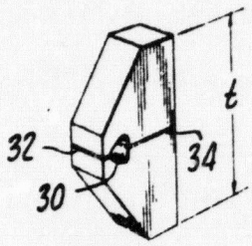


FIG_7

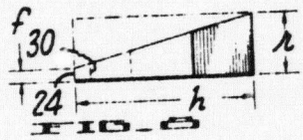


FIG_8

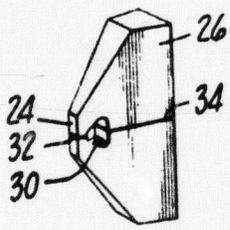


FIG_9

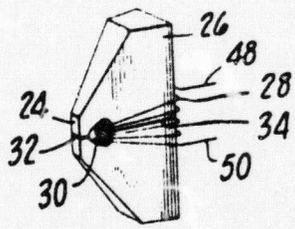


FIG_10

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United States Patent Office

3,283,396

Patented Nov. 8, 1966

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3,283,396

# MAGNETIC TRANSDUCER ASSEMBLY AND MANUFACTURE

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Original application Apr. 17, 1961, Ser. No. 103,424. Divided and this application May 12, 1964, Ser. No. 377,445

3 Claims. (Cl. 29—155.5)

This is a division of application Serial No. 103,424 filed April 17, 1961.

This invention relates to a method and means for manufacturing magnetic transducers, and in particular to a method and means for making and employing magnetic heads formed substantially from a ferrite material.

Ferrites are highly preferable for use as cores of magnetic transducers or heads because they are relatively hard, afford lower losses during the recording and reproducing modes, and operate well at high frequencies. When techniques normally utilized for construction of magnetic tape transducers from metallic magnetic materials and specifically, the techniques of forming the nonmagnetic gap are employed in the construction of a magnetic tape transducer intended for contact recording, such a transducer assembly being formed from ferrite, the well-defined, sharp corners of the ferrite material at the junction formed by the nonmagnetic gap and the ferrite have a tendency to chip and crack and, in general, erode away until satisfactory operation of the transducer is no longer possible due to poor resolving power.

In the prior art, heads utilizing ferrite cores have been made with metallic pole places, such as Alfenol, disposed on either side of the nonmagnetic gap to provide a mechanically strong structure. However, such a head structure is subject to rapid wear requiring frequent replacement when operating in contact with magnetic tapes, especially at high relative speeds. Furthermore, changes in structure of the head due to abrasion and wear vary the resolution and sensitivity characteristics of the head. In addition, the manufacture of such heads is tedious, time-consuming and uneconomical because they must be manufactured individually to provide proper gap dimensions.

It has been proposed to employ a glass bond or embedment to form the nonmagnetic gap of a ferrite core transducer to provide improved head wear resistance, to minimize gap erosion, and to provide improved gap definition, better resolution and greater sensitivity. But the manufacture of glass gap heads for use in video, television or high frequency magnetic tape apparatus necessitates special techniques. For example, in a television tape recorder that utilizes a plurality of expensive magnetic heads having relatively narrow gaps disposed circumferentially on a rotary drum, the heads need be perfectly aligned and properly adjusted to avoid phasing errors and improper head-to-tape contact. Therefore, it would be desirable to provide a method for manufacturing ferrite core magnetic heads by mass production methods wherein all the heads have substantially the same precise configuration, and still derive the advantages and features of a ferrite core head having a gap formed by means of a glass bond.

An object of this invention is to provide a novel and improved method for manufacturing a magnetic transducer utilizing a ferrite material as the core.

Another object of this invention is to provide an improved method for forming a ferrite core transducer having a relatively narrow nonmagnetic gap with a nonmagnetic rigid material disposed in the gap to provide structural strength.

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Another object is to provide a method for manufacturing precisely formed ferrite core heads having accurate gap dimensions on a mass production basis in an economical manner.

Another object of this invention is to provide a method for forming a magnetic transducer having a ferrite core and a glass gap, such glass forming a chemical bond so as to establish a substantially continuous molecular structure but a discontinuous magnetic structure.

According to this invention, a plurality of lapped and polished ferrite slabs of high density and low porosity have a series of spacer layers or strips deposited on one surface, the thickness of such layers determining the gap length of a finished transducer. A like plurality of similar ferrite slabs are coated with a thin layer of glass on a corresponding surface, such glass having a coefficient of thermal expansion essentially the same as that of the ferrite material. All the slabs are sliced transversely to the parallel spacer strips into ferrite blocks. Each ferrite block having spacer strips is fused to a block having a glass layer, by heating the glass to melting while the blocks are clamped under high pressure in a neutral atmosphere. After cooling, the joined blocks are severed along the spacer strips to provide transducer size units having a nonmagnetic glass gap ready for further shaping and assembly. The shaped and finished transducer assemblies are all substantially uniform in dimension and physical characteristics, and a multiplicity of such mechanically stable transducers may be mounted in equally spaced relation about the periphery of a rotary drum assembly of a magnetic tape apparatus to provide recording and reproducing operation that has high resolution and improved sensitivity.

In an embodiment of this invention, a ferrite material having relatively high density and low porosity is cut and lapped into rectangular type slabs, which are polished and then heated to eliminate any contaminants. A plurality of parallel layers of spacer material having a high melting point are deposited longitudinally on one surface of half of the slabs, and a thin layer of glass having a relatively low melting temperature is deposited coextensively on a corresponding surface of the other half of the slabs. The slabs having the spacer material are then cut transversely relative to the length of the spacer strips, and the slabs having the glass are cut along the same transverse dimension thereby providing ferrite blocks with one dimension that is close to the overall height of the finished transducer.

Each ferrite block having the spacer strips is fused to a ferrite block having a layer of glass under very high pressure, thus causing the two blocks to settle together against the spacer material, thereby forcing the melted glass that is present in excess to flow out from between the blocks. The blocks are thus joined at the surfaces carrying the spacer and glass material respectively, thereby forming a magnetic body having a nonmagnetic layer disposed in a substantially central plane therein that will serve as the nonmagnetic gaps of several magnetic transducers or heads. The joined block assembly has portions cut back to provide a smaller surface for contacting a magnetic tape that will cooperate with such surface during the recording or reproducing modes. The block assemblies are then partitioned into transducer size units by cutting along the lines of the spacer strips thereby entirely eliminating the spacer material. Thus, a plurality of unitary or integral transducer units in the form of fused ferrite block portions, each having a nonmagnetic gap material of glass centrally secured therein that forms a molecular bond with the ferrite, are provided ready for further machining to a desired shape.

To accommodate an energizing coil such as is conventionally used with magnetic transducers, an aperture

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is formed in the transducer unit along the plane of the rigid gap material through a portion thereof close to the effective gap face at a predetermined location. The effective gap face or front gap surface is defined as that surface which the magnetic tape traverses during operation of the magnetic tape apparatus. In contrast to the rear gap surface that is not employed directly in the transducing process. Thus, a high reluctance magnetic path is provided by disposition of the aperture adjacent to the effective gap.

The transducer is then tapered to a wedge-like shape converging from the rear gap surface to the front gap surface so that the width of the effective gap, i.e., the dimension of the surface of the front gap perpendicular to the longitudinal movement of the tape, corresponds closely to the width of the tape track to provide enhanced sensitivity by virtue of the large rear gap area as compared to the front gap area, thereby providing a considerably lower rear gap reluctance than would exist if the entire transducer were constant in thickness. However, since the width of the rear gap surface is maintained substantially larger, additional structural strength is provided for the transducer assembly. After tapering of the transducer unit, the energizing coil is coupled to the transducer.

The finished transducer assembly having the wedge shape is then joined by means of an assembly jig to a nonmagnetic mounting shoe having a cooperating wedge-like cutout. The shoe is precisely positioned on a rotary drum assembly of a magnetic tape apparatus in a similar relation as when positioned on the jig so that the transducer becomes fixed on the drum whereby only a predetermined gap portion projects from the drum periphery for contact with a magnetic medium or tape. When a plurality of shoe mounted transducers are assembled to the rotary drum, the precision mounting of transducer to shoe and shoe to drum assures that all the transducer front gap faces protrude substantially the same amount from the periphery of the drum along a radial direction. Furthermore, simple means are provided to adjust the quadrature or phasing relation of the transducers, and once such adjustment is made, such relation remains fixed during operation for practical purposes.

The invention will be described in greater detail with reference to the drawing in which:

FIGURE 1 is a flow chart setting forth various steps of the inventive method;

FIGURE 2 is a perspective view of a cut and polished ferrite slab having space; layers deposited thereon, in accordance with the invention;

FIGURE 3 is a perspective view of a cut and polished ferrite slab having a glass layer deposited thereon;

FIGURE 4 is a perspective view of two ferrite blocks cut from the slabs of FIGURES 2 and 3 respectively, and processed ready for joining;

FIGURE 5 shows a joined ferrite block assembly that has been cut back, according to the invention;

FIGURE 6 represents a transducer size ferrite unit partitioned from the assembly of FIGURE 5;

FIGURE 7 illustrates a transducer unit with an aperture formed therein;

FIGURE 8 is an enlarged end view of the same transducer unit after tapering, in accordance with one aspect of the invention;

FIGURE 9 depicts the shaped transducer unit of FIGURE 8 in a front perspective view; and

FIGURE 10 shows a shaped transducer with an energizing coil coupled thereto fabricated in accordance with the method of the invention.

To aid in the explanation of the invention, the following letters will be used hereinafter as follows:

*t*—the overall length of the transducer unit in the direction of tape travel

*f*—the width of the front gap surface that is perpendicular to the direction of the moving tape, and that approximates the width of a tape track that will cooperate with the transducer during record of reproduce operation

*r*—the width of the rear gap surface that is parallel to the dimension *f*

*h*—the height of the transducer unit measure from the effective gap face or front gap surface to the rear gap surface, and orthogonally to both surfaces



Similar numerals and designations refer to similar elements throughout the drawing.

In accordance with an embodiment of the invention, a ferrite body that may be formed from a ferrite material is cut, parallel lapped into several rectangular slabs, and one longitudinal surface of each slab is polished to a specular finish under a high pressure of about 60–100 lbs. per square inch on an optically smooth surface. As indicated in the flow chart of FIGURE 1, the ferrite slabs are heated or "cooked" at about 600° centigrade to remove undesirable contaminants. Thereafter, one half of the slabs **10** have a series of evenly spaced parallel linear layers of spacer material **12** deposited thereon, as shown in FIGURE 2. The thickness of the slab **10** may be about one half of the desired overall length, *t*, of the finished transducer, *t* being about .250 inch. The spacer material **12** may be silicon monoxide or aluminum oxide, for example, that has been deposited by evaporation, spraying, or other known methods for depositing a precise thickness of material. Each spacer strip **12** may be approximately .008 inch wide and approximately 80 micro-inches deep, by way of example, such layer thickness being instrumental in determining the ultimate effective gap length. The spacing between each of the strips may be .046 inch, for example, such dimension serving to determine the approximate extent of *r*, the rear gap surface, and also to limit the width, *f*, of the effective front gap surface.

On the other half of the slabs **14**, a thin glass layer **16** is deposited, as shown in FIGURE 3, coextensively on a surface corresponding to the surface of the slab **10** on which the spacer material **12** is deposited. The glass **16**, which has a low melting temperature relative to the spacer material **12** and a coefficient of thermal expansion substantially the same as that of the firrite, preferably is noncorrosive, and is of such composition that the magnetic properties of the ferrite are not affected by fusion of the ferrite and glass. The glass layer **16** may be melted onto the ferrite slab **14** at about 550–900° centigrade, which temperature is sufficient to soften the glass and to cause the glass to wet the ferrite.

With the slab **10** properly dimensioned, and each surface in orthogonal relationship to the adjacent surfaces, the ferrite slab **10** with the spacer material is cut transversely to the spacer strips **12** to provide blocks **18** such as shown in FIGURE 4, such blocks **18** having a dimension approximately the overall height *h* of the finished transducer. At the same time, the ferrite slab **14** is cut along the same dimension as the slab **10** to provide glass coated blocks **20**, such as shown in FIGURE 4, for joining with the blocks **18**.

The ferrite blocks **18** and **20** are joined by setting the glass coated block **20** onto the block **18** with the surface having the spacer lines **12** facing the corresponding surface having the glass layer **16**. With the blocks **18** and **20** securely fixed relative to each other, high pressure of about 3000 lbs. per square inch may be applied when the glasss commences to soften, urging the blocks closer together until both surfaces are resting against the spacer strips. The block assembly **22** is heated in a neutral atmosphere, such as in an environment of an inert gas as argon, at a temperature between 550–900° centigrade which is sufficient to allow the excess melted glass to flow from between the blocks. The glass **16**, having a relatively low melting point, flows and fills in the areas between the layers of spacer material **12**, and the excesss glass is forced out from between the continuous surfaces during the fusing process. The assembly **22** is cooled to an ambient rom temperature thereby causing the blocks

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18 and 20 to be integrally joined by means of the glass bond 16 that has a thickness of approximately 80 microinches, such as determined by the thickness of the spacer material 12.

The joined assembly 22 is lapped and polished, and the gap width is checked and inspected under a microscope. At this point, the assembly 22 is ground down by cutting back at about a 30° angle at each end of the front gap surface until the total area of the front gap surface is reduced in length *t* from .25 inch to about .080 inch, as indicated in FIGURE 5. The reduced front gap surface allows satisfactory unit pressure at the gap area to be obtained with a low total force between the transducer and the tape. This low total force subjects the recording medium to decreased mutilation and lessens the frictional effects thus preventing oxide deposits from building up on the transducer and providing increased tape life.

Thereafter, the joined assembly 22 is partitioned by cutting along the spacer lines 12, with a diamond saw that has a width of about .013 inch, for example, which is slightly larger than the .008 inch width of the spacer layers, thus eliminating the spacer material 12 from the ferrite assembly 22. Also, as the .008 inch wide layers are spaced at about .040 inch, the cutting operation provides gap faces, rear and front respectively, that are each about .035 inch wide. The severed units or blanks are now in a desired transducer size 26, as shown in FIGURE 6, and need only be shaped to a desired configuration and wired to serve as a magnetic recording or reproducing head.

To allow for electrical coupling of an energizing coil 28 to the transducer unit 26, an aperture 30 of about .025 inch in diameter is drilled along the plane of the glass bond 16 through the transducer unit 26, but asymmetrically relative to the front gap 32 and rear gap 34 (FIGURE 7). The aperture 30, which may be formed by ultrasonic means for example, is located preferably close to the effective front gap 30, about 0.28 inch from the aperture center to the front gap surface 24, to provide a high reluctance magnetic path adjacent thereto. The aperture 30 is preferably pear shaped to provide increased mechanical strength and reduced reluctance in the area adjacent to the front gap.

In accordance with another feature of the invention, the transducer unit 26 is shaped into a wedge-like form by tapering one side from the rear gap 34 to the front gap 32 at about an angle of 14°, as illustrated by FIGURES 8 and 9. Improved sensitivity is afforded because of the ratio of the reluctance of the front gap 32 relative to that of the rear gap 34 is increased, and at the same time a strong mechanical structure is provided. The wedge type transducer 26 conforms with a rotary drum mounting shoe 36 that has an accommodating retaining cutout portion 38, such as shown in U.S. patent application 103,424. Finally, as shown in FIGURE 10, a coil 28 of insulated copper wire for transducing the processed signal, is wound through the aperture 30 and around the rear gap portion and surface of the transducer 26.

While the above description has shown, described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the method illustrated may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. The method of forming magnetic transducer assemblies comprising the steps of: depositing spacer strips of material having a relatively high melting point longitudinally on a surface of a lapped and polished ferrite slab having a predetermined configuration; depositing a thin layer of glass on a corresponding surface of another polished ferrite slab, said slabs having substantially the same configuration and physical characteristics; cutting the slabs in a direction transverse to the longitudinal strips of spacer material to form blocks having desired dimensions; joining each of the blocks containing spacer material with each of the glass coated blocks in an atmosphere having a temperature of about 550–900° centigrade under high pressure to form a nonmagnetic gap layer between said formed blocks; cutting the joined assembly along the longitudinal strips of spacer material perpendicular to the joined surfaces to remove said spacer material and provide transducer size units and define sides of said units; forming an aperture along a portion of the gap layer in each of said transducer units to define front and rear gaps; and winding an electrical coil through said aperture.



2. The method of claim 1 further comprising: shaping at least one of said sides of each unit to form a planar surface extending through said front and rear gaps and inclined to the other side surface.

3. The method of forming a plurality of magnetic transducer assemblies comprising the steps of: cutting a ferrite body having high density and low porosity into a rectangular form; parallel cutting said rectangular form to provide an even number of slabs having surfaces that are disposed substantially orthogonally to each other; polishing a surface of each of said slabs to a specular finish; heating said slabs at a temperature of about 600° centigrade to eliminate contaminants therefrom; depositing parallel strips of silicon monoxide on said polished surface of each of one half of said slabs for providing spacer strips; depositing a thin glass layer coextensive with a corresponding polished surface on each of the other half of said slabs; cutting said one half of said slabs transversely to the spacer strips to provide ferrite blocks having a predetermined configuration; cutting said other half of said slabs to substantially the same configuration as that of said half of said slabs to form similar blocks; joining each block having spacer strips thereon to a block having a glass layer at a temperature between 550–900° centigrade with a pressure of about 3,000 pounds per square inch applied to urge said blocks closely together; cutting back a front gap surface of said joined block assemblies at about 30° to provide a substantially lesser area for magnetic tape contact; cutting along and removing the spacer strips of said joined assemblies to define sides and to provide transducer size units; forming an aperture in each of said transducer units through a portion of said glass gap layer and closely adjacent to said front gap surface; tapering one side of said transducer size unit from the rear gap surface to the front gap surface; and winding an electrical coil through said aperture and around said transducer unit.


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JOHN F. CAMPBELL, *Primary Examiner.*

R. W. CHURCH, *Assistant Examiner.*

PLAINTIFF'S EXHIBIT 151

Nov. 9, 1965 J. S. HANSON 3,217,305

GLASS BONDED FERRITE MAGNETIC HEAD

Filed July 19, 1962

FIG. 1

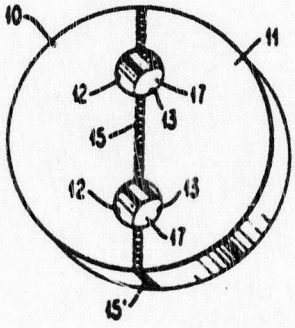



FIG. 2

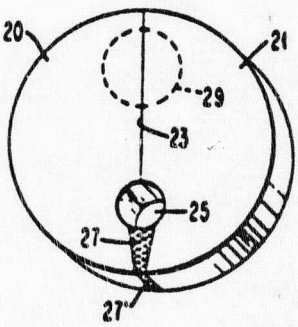



FIG. 3

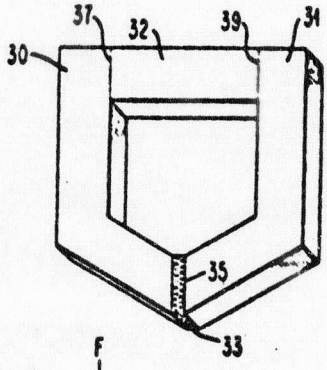



FIG. 4

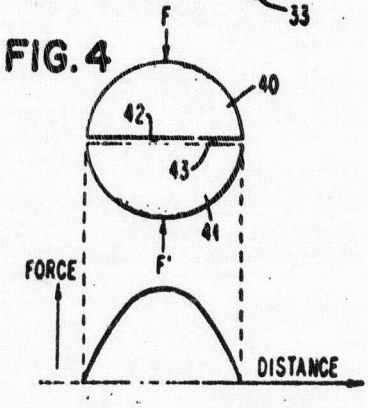



FIG. 6

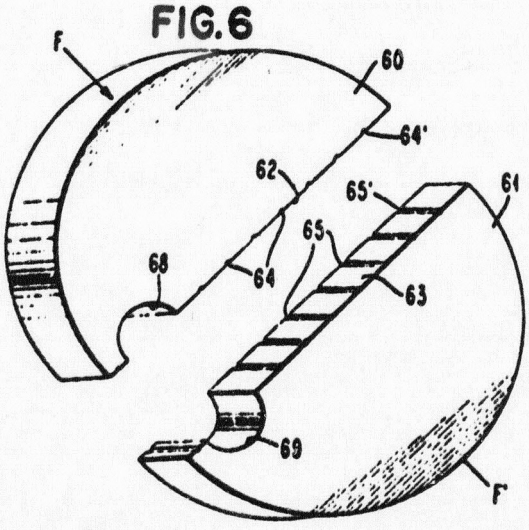



FIG. 5

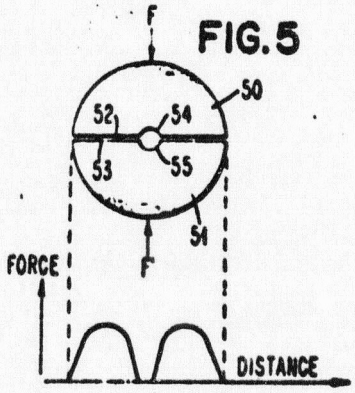
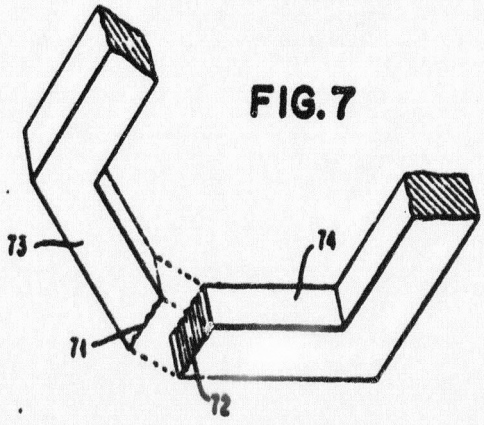



FIG. 7

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PLAINTIFF'S EXHIBIT 151

United States Patent Office

3,217,305
Patented Nov. 9, 1965



3,217,305

# GLASS BONDED FERRITE MAGNETIC HEAD

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Filed July 19, 1962, Ser. No. 211,016
4 Claims. (Cl. 340—174.1)

This invention relates to improvements in magnetic heads of the type in which ferrite pole pieces are fused together with glass.

The magnetic recording art has recently been advanced by the introduction of high frequency magnetic heads which are formed by bonding together appropriately shaped ferrite pieces with glass. As is known in the magnetic head art, the process of making such heads consists generally of forming ferrite structures of sintered ferromagnetic oxide in such a size and shape so that, when bonded together, they will provide the main body portion of a magnetic head. The structures are then placed face to face with a small quantity of glass between them. The glass generally has a thermal expansion coefficient which is very much like that of the ferrite. The ferrite pieces with the glass between them are then heated to a point where the glass melts, and proper pressure is applied so as to cause excess glass to squeeze out, and to leave just sufficient glass between the ferrite pieces as will form a gap of proper proportions. The amount of pressure used is determined by the characteristics of the glass, including viscosity, the area of the surfaces which will form the bond, the temperature used, and the length of the time period of temperature and pressure application.

The manufacture of this type of magnetic head has for the most part been satisfactory. However, it has proven to be difficult if not impossible to achieve, with regularity, gap widths of forty or fifty microinches. Since the high frequency limitation of a magnetic head is in part determined by the width of the gap, it is necessary to provide as narrow a gap as possible in order to utilize the advantages of glass bonded ferrite heads.

It is therefore the main object of this invention to provide a ferrite magnetic head with a gap which is more narrow than has heretofore been available.

Another object is to provide a glass bonded ferrite magnetic head having a more uniform gap thickness over the entire gap.

A further object is to provide a glass bonded ferrite magnetic head which is capable of being manufactured to closer tolerances, and with a predictable uniformity of dimension amongst all heads made, as well as a more constant dimension control over the entire gap of each head, whether the gap is tapered or parallel.

In accordance with the present invention, the ferrite pieces, which are to be bonded together with glass so as to form a magnetic head, are provided with a plurality of grooves on the bonding surfaces. The grooves enhance the flow of molten glass in the bonding area, and also provide for an improved distribution of force across the entire bonding surfaces.

This invention permits manufacture of glass bonded ferrite magnetic heads with more uniform distribution of glass between the ferrite pieces, and with a smaller and more predictable width of gap.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments thereof, as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is a perspective of a glass bonded ferrite magnetic head having two apertures therein;

FIG. 2 is a perspective of a glass-bonded ferrite magnetic head having a tapered front gap, a single aperture, and no back gap;



FIG. 3 is a perspective of a conventional glass bonded ferrite magnetic head;

FIG. 4 is a comparative illustration of the distribution of pressure across the mating surfaces of a pair of semicircular ferrite pieces as a function of an applied force;

FIG. 5 is an illustration of the pressure distribution across the mating surfaces of a pair of ferrite pieces which results from modifying the device of FIG. 4 by cutting a groove midway in each of the bonding surfaces;

FIG. 6 is a perspective of a pair of ferrite pieces which may be glass bonded so as to form a magnetic head generally of the type shown in FIGS. 1 and 2, and having grooves in the bonding surfaces thereof in accordance with one embodiment of the invention;

FIG. 7 is a perspective of a pair of ferrite pieces for use in forming a magnetic head generally of the type shown in FIG. 3 and having grooves formed in the bonding surfaces thereof in a manner similar to that shown in FIG. 6, in accordance with a further embodiment of the invention.

FIGS. 1, 2 and 3 illustrate generally glass bonded ferrite magnetic head structures which are merely representative of the many structures known in the prior art. Each of these structures may be made with or without the advantages of the subject invention, and it is the improvement of these structures to which the subject invention relates.

In FIG. 1, two ferrite pieces 10 and 11 are each formed with depressions 12 and 13, respectively, and are fused together by a glass bonding 15, as is known in the prior art. The semicircular depressions 12, 13, when combined by the bonding of the ferrite pieces 10, 11, form apertures 17 which may receive electrical windings as is well known in the prior art. The glass bonding material 15 also serves to define a front non-magnetic gap area 15' and a rear magnetic gap area (not shown) diametrically opposite to the gap area 15'.

FIG. 2 is an obvious variation in FIG. 1, in which a pair of ferrite pieces 20, 21 are butted together over a substantial area of their mating surfaces as indicated at 23. Only a single aperture 25 is provided, and only a single area of glass bonding 27 is utilized. This provides a magnetic head having a single front gap 27' and no back gap, and since the abutting surfaces 23 of the pieces 20, 21 form a substantially large portion of the diametrical cross section of the head, the reluctance of the rear section of the head (as at 23) is low compared with that of the gap 27'. A small amount of glass may be placed on opposite surfaces of the pieces 20, 21, as shown by the dotted circle 29, to add mechanical strength to the head. This has been found to be a very desirable form of high frequency magnetic recording and reproducing head.

In FIG. 3 is shown a glass bonded ferrite magnetic head comprising two pole pieces 30, 31 which may be joined directly together by a connecting ferrite piece 32. The pieces 30, 31 are shaped so as to define a substantially sharp gap 33 which is formed (as in FIGS. 1 and 2) by a glass bonding 35 that fuses together the ferrite pieces 30, 31. The joints 37, 39 may be made with glass bonding on the surfaces of the pieces 30, 31, 32 (as at 29, FIG. 2), or in any other suitable fashion.

Many other well-known magnetic head configurations are available, and it should be understood that this invention may be utilized to provide an improved glass bonded ferrite magnetic head regardless of which configuration is chosen.

Consider making the ferrite head shown in either FIG. 1 or FIG. 2. If the head is to conform to the shape shown in FIG. 1, force which is required to cause excess glass to squeeze out and leave a gap of the proper dimension would be applied diametrically, in a

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plane perpendicular to the plane of the glass 15. Referring now to FIG. 4, two ferrite pieces 40, 41 are illustrated generally with forces F, F' being applied on a diameter perpendicular to the mating surfaces 42, 43 of the two pieces 40, 41. Shown at the bottom of FIG. 4 is a diagram illustrating the distribution of force across the mating surfaces 42, 43 of the pieces 40, 41. As would be expected, the force is greatest at the very center of the mating surfaces 42, 43, and tapers off at the edges of those surfaces. This tends to provide a force concentration at the center of the bonding area (the mating surfaces 42, 43) which in turn acts somewhat like a pivot point about which either or both of the pieces 40, 41 may rotate slightly as the force is applied. In other words, if either of the forces F, F' are applied at a point other than a point which is on a diameter of the pieces 40, 41 absolutely perpendicular to the surfaces 42, 43, then the pieces would tend to be forced together to a greater degree at either the right or the left, respectively. This tends to cause the ferrite pieces 40, 41 to be fused together more closely at one end of the bonding area than at the other.

Since high frequency magnetic heads require gaps with very precise dimensions, the tendency for pivoting of the pieces 40, 41 results in the manufacture of a substantial percentage of magnetic heads which cannot be used commercially, and therefore must be thrown away. It is this problem to which the subject invention is primarily directed.

Referring now to FIG. 5, a pair of ferrite pieces 50, 51 is shown with their respective mating surfaces 52, 53 each provided with a groove 54, 55 cut across the surfaces 52, 53 midway in the middle of the surfaces 54, 55. As is well known in the art, it is impossible for force to be applied from one groove (54) to the other groove (55). Thus there have been defined two distinct surfaces for the mutual application of force between the ferrite pieces 50, 51. As shown at the bottom of FIG. 5, the force distribution for the pole pieces 50, 51 will now have two nodes. Thus, the maximum force applied at either of the two surface junctions will be less than the maximum force applied to a single surface junction (such as is shown in FIG. 4), and the maximum force is applied at two points instead of one, which removes the tendency to pivot about a single point, thereby permitting manufacture of gaps which are uniform throughout the entire dimension thereof, even though there may be a slight inclination (or lack of perpendicularity) in the forces F, F'. It should be understood that even more grooves could be made in the pieces 50, 51 thereby creating additional, smaller nodes of force, in proportion to the number of grooves which are provided.

In FIG. 6 is shown two ferrite pieces 60, 61 which may be fused together as described so as to form a glass bonded ferrite magnetic head. Each piece 60, 61 is provided with a respective surface 62, 63 which will form the mating surface of the glass bonding between the pieces 60, 61. Each of the surfaces 62, 63 is provided with grooves 64, 65, which grooves subdivide the respective surfaces 62, 63 into $N+1$ areas, where N is the number of grooves. The grooves 64, 65 therefore serve to subdivide the forces which may be applied as at F and F' into as many force nodes as there are surfaces. The pieces 60, 61 may both be made on the same machinery by the same processes, and therefore have their respective grooves 64, 65 in corresponding positions. However, this is not necessary, and the grooves 64 need not match the grooves 65 as the surface 62, 63 are bonded together. In other words, the grooves 64' need not lie directly opposite the grooves 65' in accordance with the subject invention. Similarly, it may suffice to have grooves in only one of the surfaces (i.e., 63) and not in the other (i.e., 62), depending on the size of the pieces, the diameter of the grooves, and other



design variables. The grooves 64, 65 not only subdivide the surfaces 62, 63 to provide a more stable force distribution thereacross, but also provide channels through which molten glass may flow, thereby affording relief of pressure at strategic points and therefore tending to increase the ease with which the proper gap dimension can be achieved as heat and pressure are applied. Although the grooves may be very small, it is to be understood that the distance between the pieces 60, 61 may be in the order of forty or fifty microinches after bonding is completed. Therefore, any groove at all will tend to greatly increase the cross sectional area of the space through which excess glass can flow outwardly.

For example, one ferrite head made, in accordance with the present invention, to have a gap of fifty microinches, comprises two ferrite pieces which are approximately a tenth of an inch thick having a diameter of about three tenths of an inch. In this head, eight grooves are provided on each surface 62, 63, each groove having a diameter of roughly five thousandths of an inch, for example. Thus, as the head is being formed, the two ferrite pieces are brought closer and closer together due to the applied pressure. The whole assembly is heated to such a degree that the glass is in the form of a sticky, viscous fluid. All of this viscous fluid (the glass) which is in excess of the amount necessary to fill a fifty microinch gap between the two ferrite pieces must be extruded from between the two pieces during the forming process. Without grooves between the two ferrite pieces, the worst case situation for the flow of glass exists for glass which is found along the longitudinal center line of the gap which must flow outwardly to the semicircular faces of the pole pieces in order to escape from the gap. In the head of the given example, this means that there will be a body of glass along a line three tenths of an inch long which must find its way parallel to the annular axis of the head, and perpendicular to the gap, across a mean-free path of about fifty thousandths of an inch (that is, glass can flow outwardly in two directions, in each direction it will be traveling one half of the thickness of the heads which in this example is one tenth of an inch, or 100 thousandths of an inch). However, when the grooves are added, then the glass is subdivided into $N+1$ portions, where N is the number of grooves provided. Each portion may then flow not only toward the semicircular surfaces of the heads as before described, but may now also flow in a perpendicular direction, toward each of the grooves which is provided. This tends to provide a path for glass to flow towards adjacent grooves which is one half of the distance between grooves. In the given example, this distance is about fifteen thousandths of an inch. It can be estimated roughly that this is equivalent to glass flowing outwardly from a central point to a circumferential edge portion which has a mean-free path somewhat greater than fifteen thousandths of an inch. In other words, the mean-free path is reduced from fifty to about fifteen thousandths of an inch, which roughly corresponds to approximately one third when the grooves are used compared with the head made without grooves. Furthermore, since the glass cannot only flow toward the semicircular surfaces of the ferrite pieces, but also toward the grooves, the cross sectional area of the "pipe" through which the glass can flow has been increased a substantial amount. Recalling that in the example the distance between grooves is approximately thirty thousandths of an inch and that the thickness of the pieces is approximately one tenth of an inch (and therefore the lengths of each groove are approximately one tenth of an inch), the cross sectional area of the pipes through which glass can flow has been increased from approximately sixty thousandths of an inch to approximately two hundred and sixty thousandths of an inch, which may be taken as roughly a fourfold increase. Thus there is a total increase in the viscous flow capability of glass within

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the gap area which is quite substantial when grooves are provided compared to that which obtains without the grooves.

It should be understood that this invention is concerned with surface preparation of the ferrite pieces to be joined together so as to form a glass bonded ferrite magnetic head. The invention is not concerned with how the pieces are otherwise preformed. For instance, the pieces 60, 61 are shown having semicircular cut-out portions 68, 69, respectively, which together form an aperture in the magnetic head when the pieces 60, 61 are fused together. It is immaterial to this invention whether the semicircular cutouts are formed prior to the fusion, or whether a hole is drilled by ultrasonic techniques, or otherwise, after the pieces 60, 61 are fused together. Thus the ferrite pieces may have no provisions for an aperture prior to being fused together (such as illustrated roughly in FIG. 4) or may have semicircular cut-out portions provided in each of the pieces prior to being fused (as shown in FIG. 6). Furthermore, it is immaterial whether an entire diametrical portion of the magnetic head is fused together with glass (as shown in FIG. 1 and suggested in FIG. 6) or only a small portion thereof is glass bonded as shown in FIG. 2. The point is that the glass bonding may be more effectively and consistently produced if grooves are provided in the mating surfaces of the ferrite pieces prior to being fused together.

FIG. 7 illustrates the positioning of grooves 71 and 72 in respect to ferrite pieces 73, 74 which when fused together may form a ferrite magnetic head of the type shown in FIG. 3. Thus, it can be seen that provision of grooves in the mating surfaces will enhance the glass bonding of ferrite pieces so as to form a glass bonded ferrite magnetic head of any desired configuration.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, and although the specific example of dimensions has been given with reference to FIG. 6, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A glass bonded ferrite magnetic recording and reproducing head, comprising:

a plurality of circuit parts of ferrite material, one of said parts being provided with a mating surface for ultimate fusion with the mating surface of another one of said plurality of parts, at least one of said mating surfaces having at least one recess therein, there being an effective gap between said two surfaces, said gap and at least a portion of said recess being filled with a glass material mechanically joining and bonding said two mating surfaces.



2. A magnetic recorder head for recording or reproducing magnetic recordings comprising at least two ferrite circuit parts, said circuit parts each having a bonding surface disposed substantially parallel with and proximate to the bonding surface of the other of said two circuit parts with an effective gap between said bonding surfaces, at least one of said surfaces having at least one groove therein, said groove representing an insignificant discontinuity in the thickness of said gap, said gap being filled entirely with a glass material mechanically joining and bonding to each other said bonding surfaces of said circuit parts.

3. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising at least two circuit parts of sintered ferromagnetic oxide material, said circuit parts each having a bonding surface disposed substantially parallel with and proximate to the bonding surface of the other of said two circuit parts with an effective gap between said bonding surfaces, at least one of said surfaces having at least one semicircular groove therein, said semicircular groove being parallel with the annular axis of said recording head, said gap being filled entirely with a glass material mechanically joining and bonding to each other said bonding surfaces of said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material having a coefficient of expansion substantially equal to the coefficient of expansion of said sintered ferromagnetic oxide material at the temperature at which the magnetic recorder head is used.

4. In a method of forming an annular glass bonded ferrite magnetic head which comprises sandwiching a piece of glass between two pieces of ferrite at a high temperature so that the glass becomes fused to each of the ferrite pieces thereby forming a glass mechanical bond between the pieces, the glass mechanical bond also comprising an effective non-magnetic gap between the ferrite pieces, the improvement which comprises the step of forming at least one groove in at least one of said ferrite parts upon a surface thereof to which the glass will become fused, said grooves being parallel to the annular axis of the glass bonded ferrite head.


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IRVING L. SKAGOW, *Primary Examiner.*

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# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,217,305 November 9, 1965

James S. Hanson

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the grant, lines 1 to 3, for "James S. Hanson, of Poughkeepsie, New York," read -- James S. Hanson, of Poughkeepsie, New York, assignor to International Business Machines Corporation, of New York, N. Y., a corporation of New York, --; line 12, for "James S. Hanson, his heirs" read -- International Business Machines Corporation, its successors --; in the heading to the printed specification, line 3, for "James S. Hanson, 82 Hillis Terrace, Poughkeepsie, N. Y." read -- James S. Hanson, Poughkeepsie, N. Y., assignor to International Business Machines Corporation, New York, N. Y., a corporation of New York. --.

Signed and sealed this 18th day of October 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents

PLAINTIFF'S EXHIBIT 159.

A. U.S. Patents of Which Duinker is Inventor.

B. Publications Authored (or Co-Authored) by Duinker.

U. S. Philips Corp. vs.
National Micronetics, Inc.
C. A. 71 Civ. 921 R. W.

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| 3,192,608 | Multiple Ferrite Heads With Workable Metal Screens | 6/26/61 | 7/6/65 |
| 3,233,308 | Method Of Manufacturing Magnetic Heads Having Very Short Gap Lengths | 2/26/62 | 2/8/66 |

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| Patent No. | Title | Filing Date | Issue Date |
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| 3,249,987 | Method Of Manufacturing Magnetic Heads | 3/5/62 | 5/10/66 |
| 3,272,568 | Guiding Devices | 7/9/63 | 9/13/66 |
| 3,302,268 | Method Of Manufacturing Magnetic Heads Using A Jig For Accurately Determining Gap Height | 3/5/62 | 2/7/67 |
| 3,311,781 | Circuit Comprising Writing And Reproducing Circuits Using Electroluminescent And Ferro-electric Cells | 9/29/60 | 3/28/67 |
| 3,327,633 | Dosing Pump Operating In Opposite Phases For Dosing Liquid Or Gaseous Media | 2/12/65 | 6/27/67 |
| 3,354,540 | Method Of Manufacturing Reliable Magnetic Heads Having Accurately Predetermined Dimensions | 3/5/62 | 11/28/67 |
| 3,384,880 | Disc Memory Storage Comprising Magnetic Heads Arranged Obliquely To The Track | 9/30/64 | 5/21/68 |
| 3,502,821 | Magnetic Head Having Magnetically Narrow Gap With Wide Gap Structural Support | 3/5/62 | 3/24/70 |
| 3,504,958 | Two-Dimensional Digital Light-Ray Deflection Systems | 8/2/66 | 4/7/70 |
| 3,569,988 | A Laser Color Display Device Utilizing Digital Deflectors And Dispersion Correction | 5/20/66 | 3/9/71 |
| 3,584,378 | Method Of Making Magnetic Heads With Means For Preventing Side Erosion | 9/20/61 | 6/15/71 |

PLAINTIFF'S EXHIBIT 159

PUBLICATIONS AUTHORED (or Co-Authored)

BY DUINKER

1. Magnetische Versterkers (Magnetic Amplifiers). Tijdschrift Van Het Nederlands Radiogenootschap, 19, Pages 91-114, 1954.

2. A Shifting Register Using Ferro-Resonant Flip-Flops. Applied Scientific Research, V.4, Pages 317-328, 1955.

3. On the Resolving Power in the Process of Magnetic Recording. Tijdschrift Van Het Nederlands Radiogenootschap, V.22, Pages 29-48, 1957.

4. L'Application Des Ferrites A La Modulation Dans Divers Domaines De Frequence (In French). Atti Congr. Sci. Sez. Elettronica, Nucleare, Teleradiocinematografica, Luglio 1956, 3, Parte 1, pages 571-585, 1957.

5. General Energy Relations For Parametric Amplifying Devices. Tijdschrift Van Het Nederlands Radiogenootschap, V.24, Pages 287-310, 1959.

6. (Together With Van Ommen). The Scansor, A New Multi-Aperture Rectangular-Loop Ferrite Device. Solid State Electronics, V.1, Pages 176-182, 1960.

7. An Approximate Graphical Analysis Of The Steady-State Response of Nonlinear Networks. Philips Research Reports, 8, Pages 133-147, 1953.

8. General Properties of Frequency-Converting Networks (Thesis, Delft 1957). Philips Research Reports 13, Pages 37-78 and 101-148, 1958.

9. Traditors, A New Class of Non-Engergic Non-Linear Network Elements. Philips Research Reports, 14, Pages 29-51, 1959.

10. Generalization to Non-Linear Networks of a Theorem Due to Heaviside. Philips Research Rpts. 14, Pgs. 421-26, 1959

11. Durable High-Resolution Ferrite Transducer Heads Employing Bonding Glass-Spacers. Philips Research Reports, 15, Pages 342-367, 1960.

12. Short-Wave Length Response of Magnetic Reproducing Heads With Rounded Gap Edges. Philips Research Reports, V.16, Pages 307-322, 1961.

PLAINTIFF'S EXHIBIT 159

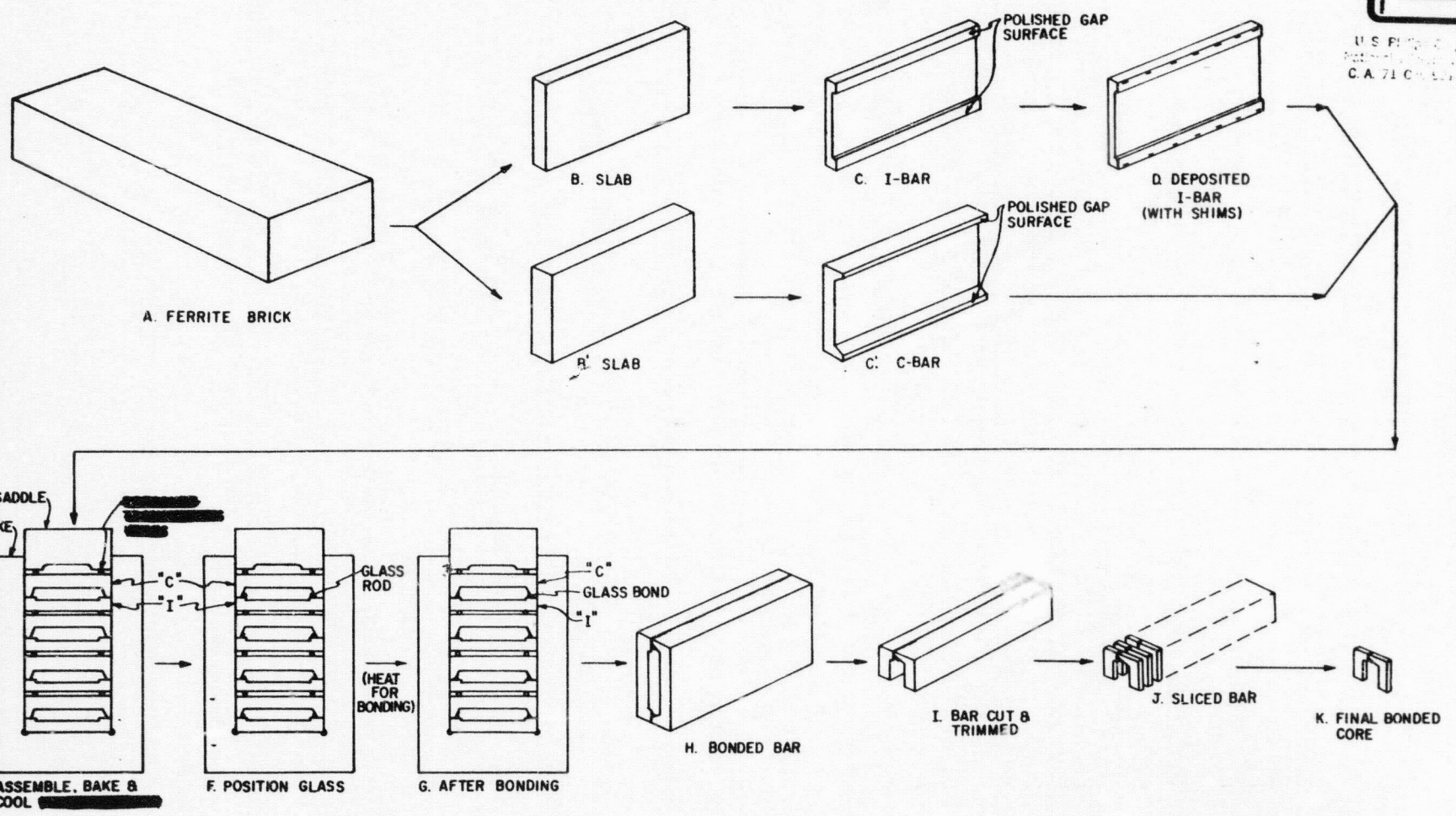
13. Conjunctors, Another New Class of Non-Energic Non-Linear Network Elements. Philips Research Reports, 17, pp. 1-19, 1962.

14. Search For A Complete Set Of Basic Elements For The Synthesis Of Non-Linear Electrical Systems. Network Theory, Pages 221-250, Pergamon Press, Oxford 1963.

15. Basic Network Elements For The Synthesis Of Non-Linear Systems. Monograph On Radio Waves And Circuits, Pages 320-329, Elsevier Publishing Co., Amsterdam, 1963.

16. (Together With Geurst). Long-Wavelength Response Of Magnetic Reproducing Heads With Rounded Outer Edges. Philips Research Reports 19, Pages 1-28, 1964.

MICRONETICS GLASS-BONDED CORE MANUFACTURING

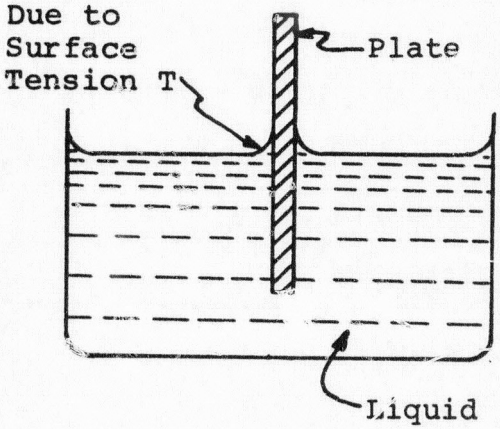



PLAINTIFF'S EXHIBIT 170.

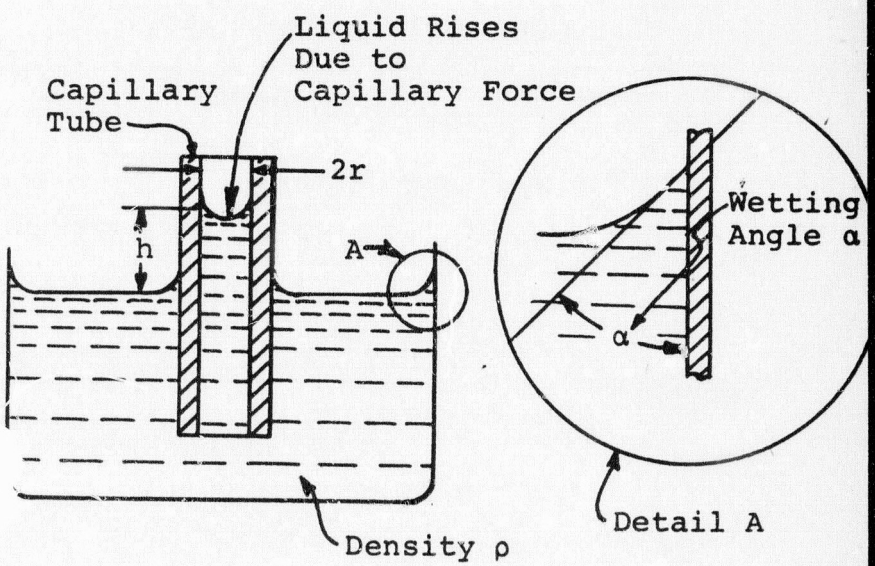
PLAINTIFF'S EXHIBIT 172.

PRINCIPLE OF CAPILLARY ACTION

A. Wetting Action




B. Capillary Action




$$h = \frac{2T \cos \alpha}{r \cdot \rho}$$

U. S. Philips Corp. vs.
National Micronetics, Inc.
C. A. 71 Civ. 921 R. W.

PATENT 3,246,383 TO H.P. PELOSCHEK, ET AL

CLAIM 1

1. A method of manufacturing portions of magnetic heads composed of

(a) two magnetic circuit parts
  (1) consisting of sintered oxidic ferromagnetic material
  (2) and having confronting gap surfaces
  (3) with a gap therebetween
  (4) filled with a nonmagnetic material bonding the circuit parts together,

comprising:

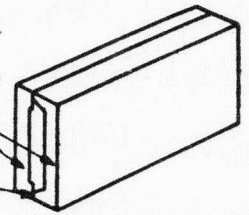
(a) placing spacing members
  (1) having a thickness equal to the desired gap length
  (2) at opposite ends of
    (i) a first polished gap surface of one circuit part,

(b) placing a corresponding polished gap surface of a second circuit part
  (1) on said spacing members
  (2) in confronting relationship with said first surface
  (3) thereby forming a gap between said surfaces,

(c) placing a quantity of nonmagnetic material adjacent to the gap,
  (1) said nonmagnetic material having a melting temperature below that of said ferromagnetic material,

(d) and heating the resulting assembly to the melting temperature of said non-magnetic material, whereby said nonmagnetic material
  (1) melts,
  (2) fills the gap by capillary action,
  (3) and bonds the circuit parts together.

PROOF OF INFRINGEMENT



Micronetics has used discrete (platinum, ferrite) spacing members (shims), H:13*B:163, and vacuum deposited silicon monoxide shims. H:64-65. See "Glass Bonded Core Manufacturing" (PX170).

See "Relation of Micronetics' Shim Heights to Gap Lengths" (PX 181). "The shim pads serve to determine the spacing of the gap". H:67.

See "Micronetics Shim Placement" (PX 182). "The shim pads are placed at the ends of either the shoulders or ledges..." H:15**.

See "Glass Bonded Core Manufacturing" (PX 170) and Micronetics' Assembly Bake and Bond Sheets (PX 56, Docs. 4093-4100). Micronetics places the corresponding surface of the second circuit part in contact with the shims so that the shim pads serve to determine the spacing of the surfaces of the gap. H:66-67.

Admitted*** [admission 3(c)]

Admitted*** [admission 3(d)]

Admitted*** [admission 3(e)]

Admitted*** [admission 3(f)]

Admitted*** [admission 3(g)]

* H:13 denotes page 13 of Hess deposition; B:163 denotes page 163 of Bubnack deposition; M(II):472 denotes page 472 of second Moon deposition.

** Testimony given referred to IBM process which is identical to the one used by Micronetics, as testified at pages 35-37 of the Hess deposition.

*** Defendants' Response to Plaintiff's Request for Admissions served 7/24/73.

PLAINTIFF'S EXHIBIT 179-A.

PATENT 3,246,383 TO H.P. PELOSCHEK, ET AL

CLAIMS 2 AND 4

PROOF OF INFRINGEMENT

2. A method according to claim 1 wherein said nonmagnetic material is glass.

Admitted*** [admission 3(h)]

4. A method according to claim 1, wherein pressure is applied to the assembly during the heating step.

Admitted*** [admission 3(j)]



PLAINTIFF'S EXHIBIT 179-B.

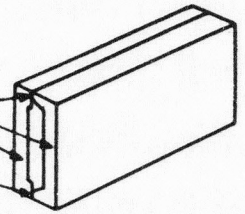
PATENT 3,246,383 TO H.P. PELOSCHEK, ET AL

PROOF OF INFRINGEMENT

CLAIM 6

6. A method of manufacturing portions of magnetic heads composed of

(a) two circuit parts
  (1) consisting of sintered oxidic ferromagnetic material
  (2) and having gap surfaces
  (3) with a gap therebetween
  (4) filled with a nonmagnetic material bonding the circuit parts together,



comprising:

(a) placing spacing members

  (1) having a thickness equal to the desired gap length

  (2) at opposite ends of

    (i) at least two polished gap surfaces of one circuit part,

Micronetics has used discrete (platinum, ferrite) spacing members (shims), H:13,*B:163,* and vacuum deposited silicon monoxide shims. H:64-65. See "Glass Bonded Core Manufacturing" (PX170).

See "Relation of Micronetics' Shim Heights to Gap Lengths" (PX 181). "The shim pads serve to determine the spacing of the gap". H:67.

See "Micronetics" Shim Placement" (PX 182). "The shim pads are placed at the ends of either the shoulders or ledges..." H:15**.

(b) placing the corresponding polished gap surfaces of a second circuit part

  (1) on said spacing members

  (2) in confronting relationship with the gap surfaces of said one circuit part

  (3) thereby forming gaps between said surfaces,

See "Glass Bonded Core Manufacturing" (PX 170) and Micronetics' Assembly Bake and Bond Sheets (PX 56, Docs. 4093-4100). Micronetics places the corresponding surface of the second circuit part in contact with the shims so that the shim pads serve to determine the spacing of the surfaces of the gap. H:66-67.

(c) placing a quantity of nonmagnetic material adjacent to the gaps,

Admitted*** [admission 3(c)]

  (1) said nonmagnetic material having a melting temperature below that of said ferromagnetic material,

Admitted*** [admission 3(d)]

(d) and heating the resulting assembly to the melting temperature of said nonmagnetic material, whereby said nonmagnetic material

Admitted*** [admission 3(e)]

  (1) melts,

Admitted*** [admission 3(f)]

  (2) fills the gaps by capillary action,

  (3) and bonds the circuit parts together,

Admitted*** [admission 3(g)]

(e) cooling the assembly,

(f) and then cutting the assembly along mutually perpendicular axes

  (1) to form a plurality of head portions.

Admitted*** [admission 3(1)].

PLAINTIFF'S EXHIBIT 179-C.

PLAINTIFF'S EXHIBIT 179-C

PATENT 3,246,383 TO H.P. PELOSCHEK, ET AL

CLAIM 10

10. A method of manufacturing portions of magnetic heads composed of

(a) two circuit parts
- (1) consisting of sintered oxidic ferromagnetic material
- (2) and having confronting gap surfaces
- (3) with a gap therebetween
- (4) filled with a nonmagnetic material bonding the circuit parts together,

comprising:

(a) placing a polished gap surfaces of one circuit part in confronting relationship with a corresponding polished gap surface of a second circuit part,

(1) said surfaces being separated by a gap equal to the desired gap length,

(b) placing a quantity of nonmagnetic material adjacent to the gap,

(1) said nonmagnetic material having a melting temperature below that of said ferromagnetic material,

(c) and heating the resulting assembly to the melting temperature of said nonmagnetic material,

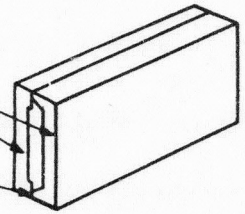
(d) whereby said nonmagnetic material

(1) melts,

(2) fills the gap by capillar action,

(3) and bonds the circuit parts together.

PROOF OF INFRINGEMENT



See "Glass Bonded Core Manufacturing " (PX 170) and Micronetics' Assembly Bake and Bond Sheets (PX 56). Micronetics places the corresponding surface of the second circuit part in contact with the shims so that the shim pads serve to determine the spacing of the surfaces of the gap. H:66-67. See "Relation of Micronetics' Shim Heights to Gap Lengths" (PX 181).

Admitted*** [admission 3(c)]

Admitted*** [admission 3(d)]

Admitted*** [admission 3(e)]

Admitted*** [admission 3(f)]

Admitted*** [admission 3(g)]

PLAINTIFF'S EXHIBIT 179-D.

PATENT 3,246,383 TO H.P. PELOSCHEK, ET AL

CLAIM 14

14. A method of manufacturing portions of magnetic heads composed of

(a) two circuit parts
(1) consisting of sintered oxidic ferromagnetic material
(2) and having confronting gap surfaces
(3) with a gap therebetween
(4) filled with a nonmagnetic material bonding the circuit parts together,

comprising

(a) heating the circuit parts,

(b) cooling the circuit parts,

(c) placing a polished gap surface of one circuit part in confronting relationship with a corresponding polished gap surface of another circuit part,

(1) said surfaces being separated by a gap equal to the desired gap length,

(d) placing a quantity of nonmagnetic material adjacent to the gap,

(1) said nonmagnetic material having a melting temperature below that of said ferromagnetic material,

(e) and heating the resulting assembly to the melting temperature of said nonmagnetic material,

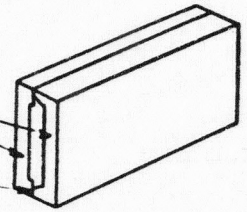
(f) whereby said nonmagnetic material

(1) melts,

(2) fills the gap by capillary action,

(3) and bonds the circuit parts together.

PROOF OF INFRINGEMENT



Micronetics heats and cools the circuit parts. See steps 6 and 7 of Standard Operating Procedure (SOP) Sheet 85504 (PX 56, Doc. 4028); M(II):472,476; See also Assembly Bake and Bond Sheets (PX 56, Docs. 4095-4100), Operation Sheets for Bonded Bars (PX 64, Docs. 12030-12036) and "Thermal Etching" (PX 183).

See "Glass Bonded Core Manufacturing " (PX 170) and Micronetics' Assembly Bake and Bond Sheets (PX 56). Micronetics places the corresponding surface of the second circuit part in contact with the shims so that the shim pads serve to determine the spacing of the surfaces of the gap. H:66-67. See "Relation of Micronetics' Shim Heights to Gap Lengths" (PX 181).

Admitted*** [admission 3(c)]

Admitted*** [admission 3(d)]

Admitted*** [admission 3(e)]

Admitted*** [admission 3(f)]

Admitted*** [admission 3(g)]

PLAINTIFF'S EXHIBIT 179-E.

449a

PATENT 3,246,383 TO H.P. PELOSCHEK, ET AL

CLAIM 15

15. A method of manufacturing portions of magentic heads composed of

(a) two circuit parts
  (1) consisting of sintered oxidic ferromagnetic material
  (2) and having confronting gap surfaces
  (3) with a gap therebetween
  (4) filled with a nonmagnetic material bonding the circuit parts together,

comprising:

(a) thermally etching the gap surfaces of the two circuit parts,

b placing a polished gap surface of one circuit part in confronting relationship with a corresponding polished gap surface of another circuit part,

  (1) said surfaces being separated by a gap equal to the desired gap length,

(c) placing a quantity of nonmagnetic material adjacent to the gap,

  (1) said nonmagnetic material having a a melting temperature below that of said ferromagnetic material,

(d) and heating the resulting assembly to the melting temperature of said nonmagnetic material,

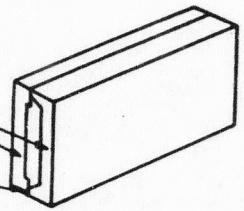
(e) whereby said nonmagnetic material

  (1) melts,

  (2) fills the gap by capillary action,

  (3) and bonds the circuit parts together.

PROOF OF INFRINGEMENT



Micronetics thermally etches the gap surfaces of the two circuit parts. See "Thermal Etching" (PX 183). See also steps 6 and 7 of SOP Sheet 85504 (PX 56, Doc. 4028); M(II):472, 476; Assembly Bake and Bond Sheets (PX 56, Docs. 4095-4100); Operation Sheets for Bonded Bars (PX 64, Docs. 12030-12036).

See "Glass Bonded Core Manufacturing " (PX 170) and Micronetics' Assembly Bake and Bond Sheets (PX 56). Micronetics places the corresponding surface of the second circuit part in contact with the shims so that the shim pads serve to determine the spacing of the surfaces of the gap. H:66-67. See "Relation of Micronetics' Shim Heights to Gap Lengths" (PX 181).

Admitted*** [admission 3(c)]

Admitted*** [admission 3(d)]

Admitted*** [admission 3(e)].

Admitted*** [admission 3(f)]

Admitted*** [admission 3(g)]

PLAINTIFF'S EXHIBIT 179-F.

450a

PLAINTIFF'S EXHIBIT 213.

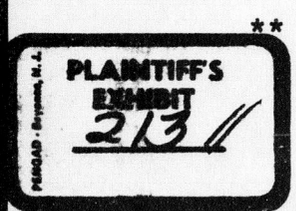
SALES OF GLASS-BONDED FERRITE CORE AND HEAD PRODUCTS

| | FERROXCUBE | MICRONETICS* |
|---|---|---|
| 1966 | $ 935,000 | - |
| 1967 | 531,000 | - |
| 1968 | 836,000 | - |
| 1969 | 1,787,000 | $ 81,000** |
| 1970 | 3,468,000 | 1,170,000 |
| 1971 | 1,889,000 | 1,351,000** |
| 1972 | 760,000 | 798,000 |
| 1973 | 2,430,000 | 2,646,000 |
| 1974 | 1,475,000 | 1,272,000 (6 months) |

CONFIDENTIAL

* From defendants' response (served February 14, 1975) to plaintiff's interrogatories 43-46, 47 (except part a), 53F and 72 (served November 13, 1974).

** Total sales of Micronetics (no breakdown maintained).




U. S. Philips Corp. vs.
National Micronetics, Inc.
C. A. 71 Civ. 921 R. W.

PLAINTIFF'S EXHIBIT 220-2.

J O H N P. M O O N , having been first duly sworn, was examined and testified as follows:

EXAMINATION BY

MR. RELSON:

Q Will you state your name, please?

A John P. Moon.

Q Where do you reside?

A Creek Road, R.D. 1, Staatsburg, New York.

Q Mr. Moon, are you employed by National Micronetics, Inc.

A What was that last part?

Q Inc.?

A Yes, I am.

Q What is your position?

A I am -- my title is manager of the engineering department.

Q How long have you been employed by this company?

A Since May of 1969.

Q Are you a graduate engineer?

(Continued on next page)

PLAINTIFF'S EXHIBIT 220-2
Moon 4

A I don't hold a degree, no.

Q Do you have a college degree?

A No.

Q Do you have college training?

A Yes.

Q Would you outline for us your college training?

A Three and a half years mechanical engineering, Penn State University.

Q Yes?

A Nine graduate credits, New York University.

Q Also in mechanical engineering?

A Yes.

Q When did you attend Penn State?

A 19 -- September of 1956 through '60, the fall semester.

Q Were your graduate credits at NYU taken with full time attendance at school?

A No, evenings.

Q Over what period?

A 1966 through '68, I believe or '67 -- through '68, excuse me.

Q Would you outline for us your employment from the time that you finished attending Penn State

PLAINTIFF'S EXHIBIT 220-2



until you joined the employ of National Micronetics?

A I worked at International Resistance Corporation in Philadelphia. I worked in the development laboratory. I went into the service for two years. I completed that and I went to work for IBM Corporation, development laboratory in Poughkeepsie, New York.

Q What was the period during which you worked at International Resistance?

A International Resistance, I worked there for one year, 1960 -'61. I don't remember the exact dates right now.

Q What was the period you were in service?

A '61-'63.

Q And from '63 on to '69, you were at IBM?

A No. My group, the group that I worked in at IBM, was moved to the west coast. At that time, I started evening at -- was enrolled on a special program at evening school and didn't want to leave. I worked at Krystinel Corporation in Port Chester, New York.

Q How do you spell that, please?

A K-R-Y-S-T-I-N-E-L.

Q During what period?

A That would be, '67, '68 to '69, approximately

two years. I don't remember the dates.

Q Immediately prior to working for Micronetics?

A That's correct.

Q So you worked at IBM from about '63 to '67?

A Yes.

Q Is that correct?

A In that range. I -- I am not prepared for those dates.

Q We won't hold you to them. In any event, you will have an opportunity to make corrections if you so desire.

A Yes.

Q What kind of work did you perform at IBM?

A I worked in recording head development group. I started as a mechanical processes technician.

Q And what other jobs did you hold while at IBM?

A That's -- that's the only group I worked in.

Q Did you have other jobs within that group?

A By other jobs --

Q Other than mechanical processes technician?

A My title was changed, if that is what you mean,

PLAINTIFF'S EXHIBIT 220-2



A Yes.

Q Were there any other techniques in use at that time?

A Not that I recall, no.

Q During the course of your employment, did IBM change its technique?

A Yes.

Q What did they change to?

A Glass rods rather than frit.

Q Were glass rods placed between the surfaces to be bonded together?

A No, not between the surfaces to be bonded.

Q How was the glass introduced between the surfaces to be bonded?

A It was placed in what we call the window area between two sections.

Q Would you explain what is meant by the window area?

A Our typical geometries were what we called at that time a C and an I. The C bar section had a relief in it deep enough to accept the glass rod and that portion was typically on an angle which formed what we called an apex.

Q Would you sketch for us the configuration

PLAINTIFF'S EXHIBIT 220-2



that you have just been describing in words?

A Yes. (Sketching)

Q Would you label the C bar and I bar?

A Yes. (Labeling)

Q Would you also indicate this relief that you mentioned? (Indicating)

Q By relief, do you mean the wide groove running the length of the C bar?

A Yes, I mean this entire area here is relieved or formed was another word we used.

Q What are the circles that you have drawn?

A The glass rods.

Q So you put the rods adjacent to what you call the apex; is that right?

A We call that the apex, yes.

Q The apex is where the slanted line meets the horizontal line on the C bar?

A Yes.

Q And you put the rods adjacent that apex?

A Right. (Indicating)

Q During your tenure at IBM, was epoxy bonding used for cores?

A No.

Q Were you acquainted or did you become

PLAINTIFF'S EXHIBIT 220-2



acquainted with epoxy bonding while at IBM?

A No.

Q Coming back to the diagram that you have drawn --

MR. RELSON: First let me ask that it be marked as Plaintiff's Exhibit 37.

(Diagram marked Plaintiff's Exhibit No. 37 for identification, this date.)

MR. JUDLOWE: May I see that diagram, please?

MR. RELSON: Yes. (Handing)

Q Were any other processes in use at IBM other than the glass frit process that you have mentioned and the one that is illustrated in Exhibit 37?

A Would you say that again, please.

MR. RELSON: Please read it.

(Question read)

Q I mean processes for bonding glass pole pieces?

A I don't recall any others.

Q You weren't aware of any; is that it?

A No.

Q Were you aware of the bonding process used

PLAINTIFF'S EXHIBIT 220-2



by IBM on the 2311 system?

A No.

Q What led IBM to go from the glass frit process to the process that you have indicated on Exhibit 37?

A Gap length control.

Q Do you mean that it was easier to control gap length in this later process?

A I don't know if we established that. I don't remember that -- I don't think we established that, to the best that I can remember. We were looking for better gap length control.

Q You don't recall whether that was established or not at the time?

A I don't recall.

Q Do you know whether it has been established since?

A No.

Q By the way, is there a name given or designation given to the process that you have described with respect to Exhibit 37, a short handle, in other words?

A No, not that I have ever used.

Q What did IBM call it to distinguish it

PLAINTIFF'S EXHIBIT 220-2



from the glass frit process?

A The only term that I can think of that we used was capillary soak.

Q This would be designated as the capillary soak process?

A That is the only term that I can think of, yes.

Q Then is it correct that in the furnace, the glass rods that you have shown in Exhibit 37 were melted and the glass went into the gap?

A Yes.

Q And did the glass fill the gap?

A By that, do you mean did it come all the way out?

Q Did it?

A Not in all cases.

Q But did it fill all the parts of the gap that were useful?

A Yes.

Q In this method, how was the gap length determined during the process?

A Initially?

Q Well, how in this process was the desired gap length fixed or determined?

PLAINTIFF'S EXHIBIT 220-2
Moon



A Shims.

Q And where were the shims placed?

A There are two techniques. They were placed in this fashion. (Indicating)

Q Would you label what you have drawn on Exhibit 37 as a shim?

A Yes. (Labeling)

Q And was a shim used on the other side, on the right side as well?

A Yes.

Q Were these shims only at the ends?

A No.

Q Where else were they?

A One in the center.

Q One at each end and one in the center; is that right?

A Yes.

Q And the parts between the shims were the parts where the glass was free to move into the gap from the rod?

A Yes.

Q What was the other technique that you mentioned? You said there were two techniques for determining this or setting the gap length?

PLAINTIFF'S EXHIBIT 220-2
Moon



A The shim was what -- the other technique I meant -- I referred to depositing shims rather than placing a shim there.

Q In the instance where the shims were placed, what was the material of which the shim was made?

A Platinum.

Q Any other materials?

A No. At IBM?

Q Yes.

A No. Not that I recall.

Q Was the portion of the product where the shims are located later discarded?

A Yes.

Q You spoke of deposited shims. Would you explain that?

A Vacuum deposition of the shim material through a mask.

Q And on what was that deposited?

A On to the ferrite I section.

Q Not on the C section?

A That would be -- it was typically on the I section.

Q That is,it was done on one and not both

PLAINTIFF'S EXHIBIT 220-2



at one time?

A It was done on one.

Q What was the material that was deposited?

A That's also a two-part question. Platinum was sputtered and silicon monoxide.

Q What was the depth of the deposited shim in relation to the gap length to be produced?

A 20 percent greater.

Q Why was it greater?

A The pads compressed during the bonding.

Q What do you mean by pads?

A It was deposited through a mask and in specific areas so that we had what we called pads which were typically rectangular shaped. (Indicating on diagram)

Q Mr. Moon, before we recessed, you were outlining the pads. About what was the spacing between adjoining pads?

A The spaces between pads were approximately 75 to 100 thousandths.

Q How does that compare with the length of each pad?

A Approximately the same.

Q And were the pads distributed along the entire length of the bar?

PLAINTIFF'S EXHIBIT 220-2



A Yes, they were.

Q Near one edge?

A Yes.

Q In the firing operation, did the pads melt?

A I would not say they melted, no.

Q Certainly not in the case of platinum; isn't that so?

A Yes.

Q What about in the case of the silicon oxide?

A No.

Q Did they soften?

A Yes.

Q Did they bond to both of the surfaces of the gap?

A Not in the case of the platinum.

Q Did they in the case of the silicon oxide?

A To some extent, yes.

Q Were the pads left in the finished product?

A Yes.

Q During the final grinding of the product to its ultimate dimensions, were the pads left in position?

PLAINTIFF'S EXHIBIT 220-2



A Grinding by our customer -- at IBM?

Q Yes.

A Yes, they were left in position.

Q So they appeared in the final recording head?

A No.

Q Well, when were they removed? At what stage?

A Well, they were left in position but the final gap height was such that the pads had been ground away.

Q Was that true of both the platinum and the silicon oxide pads?

A Yes.

Q Were there any other departments at IBM making recording heads or components other than the one in which you worked?

A Yes.

Q What was the identifying name of the department in which you worked?

A Recording head development.

Q Were you involved in the production of recording heads?

A No.

Q And that was done elsewhere in the company?

PLAINTIFF'S EXHIBIT 220-2



A Yes.

Q During your tenure, was IBM producing recording heads by the use of bonding processes different from the ones that you have described?

A I don't know.

Q Did IBM adopt the bonding process illustrated by your Exhibit 37 at a later time for production?

A Yes.

Q Was the glass frit process used for production?

A Not that I know of.

Q Was it superseded by the process of Exhibit 37?

A In our department, it was superseded by that.

Q And in production, did the capillary soak process of Exhibit 37 supersede an earlier process?

A The production I am aware of started with this process. There was nothing to supersede. (Indicating)

Q You are not aware of whatever production there was by an earlier process?

A No.

Q That is, you are not aware?

A I don't know.

Q In connection with your development of

PLAINTIFF'S EXHIBIT 220-3.

IT IS STIPULATED AND AGREED that the examination may be subscribed and sworn to before any officer authorized to administer an oath with the same force and effect as if signed and sworn to before the Court.

oOo

ROBERT HESS, having been first duly sworn, was examined and testified as follows:

EXAMINATION BY

MR. RELSON:

Q Will you state your name, please?

A Robert Hess.

Q Where do you reside?

A P.O. Box 133, Mt. Tremper, New York.

MR. JUDLOWE: Before beginning this morning, Mr. Relson, yesterday you asked for certain materials. We have had a search for them and in fact they do exist and we produce them for you this morning.

I give you a copy of Micronetics brochure on its M400 material and another on its M310 ferrite material, another on its M209 material

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as Plaintiff's Exhibit 12.

(Data sheet on the 5,000 series recording head assemblies marked Plaintiff's Exhibit No. 12 for identification, this date.)

BY MR. RELSON:

Q Mr. Hess, I understand you are employed by National Micronetics, Inc. previously called Micronetics, Inc., right?

A Right.

Q Micronetics, Inc.?

A Right.

Q What is your position there?

A Engineer.

Q What is your title?

A Development Engineer.

Q Are you working in any particular division or branch of the company?

A Engineering.

Q Is that called the Engineering Division?

A Yes.

Q And what is the nature of your responsibilities there?

A To build prototypes.

Q Of what?

PLAINTIFF'S EXHIBIT 220-3



A Recording heads, transducer -- recording heads.

MR. RELSON: Would you read the answer back.

(Answer read)

A Recording heads. Scratch transducer.

Q How long have you been employed by this company?

A It would be three years in June.

Q Let's see, does that mean you joined the company in June of 1970?

A '69. That's four years.

Q You joined the company in June 1969?

A '69, right.

Q What college degrees do you hold?

A None.

Q Have you had any college training?

A IBM type.

Q What do you mean by IBM type training?

A 66 weeks of full time school, equivalent to two years of technical schooling.

Q Would you outline for us your employment?

A IBM, 15 years.

Q When did you join IBM?

A Right after high school.

PLAINTIFF'S EXHIBIT 220-3
Hess 7

Q When was that?

A 1954.

Q And you worked with IBM up to the time you joined Micronetics?

A Yes.

Q What type of training did you receive at IBM?

A The -- what I just mentioned, technical schooling.

Q In general, what type of engineering was covered in that training?

A It covered electronics, mechanics, physics, chemistry. Those are the basic ones.

Q Did it cover principally those areas of interest to IBM?

A Right.

Q After you finished your training, what type of job were you assigned to at IBM?

A Ferrite recording heads, development.

Q So from about 1955 on, you have been working in ferrite recording heads?

A No, no.

Q Would you give us an outline of the type of jobs you held at IBM?

A I started out as a machinist, went into time

PLAINTIFF'S EXHIBIT 220-3



keeping and accounting and administration. Then the school and then ferrite development. From then -- that was 1965 to 1968, I was in ferrites.

Q So your experience in ferrites goes back to 1965?

A Right.

Q And does your experience in recording heads also go back to 1965?

A Yes.

Q Was there a gap between 1968 and 1969?

A Yes.

Q What were you doing at that time?

A I was working in other areas of IBM.

Q What other areas?

A Vacuum technology and technical writing.

Q In your work at IBM, did you become familiar with the then current technology in making ferrite recording heads?

A Yes.

Q Was IBM active in that field?

A Yes.

Q Was it producing ferrite recording heads for its own purposes?

A Yes.

PLAINTIFF'S EXHIBIT 220-3



Q Was it producing ferrite recording heads for use by other companies?

A I don't know for sure.

Q What is your best information?

A I don't believe so.

Q Would you explain to us what kinds of recording heads were being made by IBM for its own use?

A What do you mean by what types of --

Q In general, what techniques were being followed in making the heads?

A Well, I believe it was the basic techniques of glass bonding heads.

Q When you joined the ferrite development group at IBM, were they already producing glass bonded heads?

A Yes.

Q And you learned about glass bonded heads at that time?

A Right.

Q Describe for us the process used at IBM for making the glass bonded heads.

A Machine the ferrite to the geometry required and all basic types have two sections, C and I bar

PLAINTIFF'S EXHIBIT 220-3



glass bonded together.

MR. JUDLOWE: Could I have the last part of the answer read back.

(Answer read)

A (Continuing) from there, it is machined into individual recording head components and polished to finished dimension.

Q That covers the entire process?

A Well, basically, yes.

Q You indicated that the ferrite was machined to the desired geometry in two sections; is that right?

A Right.

Q And they are called a C bar and an I bar?

A Right.

Q Is the ferrite material ferromagnetic?

A I don't know.

Q What phase of this process were you directly concerned with at IBM?

A The machining and through completion.

Q From the machining on through completion?

A Right.

Q Would you sketch for us the shapes of the C bar and the I bar to which you have referred.

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(Sketching)

Q Would you just designate which is the C bar and which is the I bar?

A Yes.

(Designating)

Q You said that they are machined to required geometry.

Does that machining include polishing the faces of the portions that will ultimately become the gap?

A Yes.

Q You said they were glass bonded together.

Would you explain in more detail how that glass bonding was accomplished?

MR. JUDLOWE: Are we talking about IBM here, Mr. --

MR. RELSON: That is right.

A Right.

(Sketching)

Glass rods are placed in those positions.

Q Would you label the glass rods that you have just indicated on this drawing?

A Yes.

(Labeling)

PLAINTIFF'S EXHIBIT 220-3



Q Yes, go ahead. How is the glass bonding done?

A The glass rods were placed in those positions.

Q Yes.

A And through elevated temperatures, glass -- glass is capillary flowed through the gap.

Q That is by capillary action, the glass is drawn into the gap?

A That is right.

Q Would you indicate on this drawing where is the gap or the gaps, if there are more than one, and lebel them, please.

(Witness indicating on sketch)

There are two gaps?

A Right.

Q How are the bars, that is, the C bar and the I bar, held during the heat treatment by which the glass is caused to flow?

A I don't understand that question.

Q What determines the positioning of the C bar and the I bar during the time that the glass is flowing into the gap?

A Duco cement holds the two together.

Q Is the spacing between the C bar and the

PLAINTIFF'S EXHIBIT 220-3



I bar important during the time that the glass is being flowed between them?

A Yes.

Q How is that spacing determined?

A By either a platinum or a havar shim.

Q Would you spell that, please.

A H-A-V-A-R.

Q And what is havar?

A I don't know the basic -- I don't know what havar is made of.

Q Is it a metal?

A It is a metal.

Q When you say shim, do you mean a spacer?

A Right.

Q Where are these spacers placed with respect to the C bar and the I bar?

A On the polished surface between the two.

Q Will you sketch a plan view of the C bar and show where the shim is in relation to it?

A Of the C bar?

Q Does it make any difference whether it is the C bar?

A Not really, no. I will just sketch a shim in here. (Sketching) It would be across the length in possibly

PLAINTIFF'S EXHIBIT 220-3



three places.

Q Would you mark the shims that you have drawn?

A Yes. (Indicating)

Q So we will better be able to see where those shims are located, would you sketch a plan view of the I bar, the lower one, and where the shims are on top of it?

(Witness sketching)

I think you have left out the center part of the I on this diagram.

(Witness sketching)

Just to state in words what you have illustrated here, is it correct that the I bar has a central slightly thinner section running the length of it and two ledges, one on either side of that central section?

A That's optional.

Q What is the other alternative?

A No relief.

Q That is,it can be a flat surface?

A Yes.

Q Then is it correct that the shims are placed at the ends of either the shoulders or ledges

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or in corresponding position if there is no ledge?

A Right.

Q And also at the center?

A Right.

Q Does the spacer determine the length of the gap in the finished product?

A Would you requestion that?

Q Do you understand what is meant by the length of the gap?

A Yes.

Q Does the spacer determine what the gap length is in the finished head?

A It does have direct bearing on the final gap length.

Q What is the bearing that it has?

A Depending upon the material, the gap could be smaller or larger than the material used for the shim.

Q How is that accomplished?

A Well --

Q How is it accomplished that the gap is smaller or larger than the shim?

A As an example, if you used platinum shim, your gap would end up several micro inches

smaller than the shim you used.

Q Why is that?

A It compresses under heat.

Q During the heat treatment by which the glass is made to flow, are the two bars held under pressure?

A Yes.

Q And it is that pressure which compresses the shim if it is of platinum?

A Right.

Q How would it be accomplished that the shim would be smaller than the ultimate gap length?

A That I haven't been able to explain.

Q Does it happen?

A Yes.

Q Under what circumstances does it happen?

A As an example, havar shim, I have found that the gap is larger than the thickness of the shim I used.

Q By approximately how much?

A It depends on the weight put on the bar.

Q And what range of differences have you determined?

A 40 to 50 micro inches.

Q You said 40 to 50?

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A In that range.

Q In your work at IBM, has glass been placed into the gap in any other way than by flowing under capillary action?

A Not to my knowledge.

Q Do you know of any such work at IBM?

A What do you mean, such?

Q Work in which the glass has been put into the gap in a manner other than by capillary action.

A I do not know.

Q When a recording head is being made, do you plan that it have a particular gap length when it is completed?

A Normally, yes.

Q Normally, you set out to accomplish a particular gap length, isn't that it?

A Right.

Q In determining the thickness of the spacer to be used, do you take into account whatever the difference may be between the thickness of the spacer and the final gap?

A Yes.

Q Then coming back to this process, I would like to get it clearly in mind.

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Is it correct that the C bar and the I bar are placed together with the shims in-between, right?

A Right.

Q And then, is the whole assembly held under some pressure?

A At which point?

Q At that time. Is that the next step?

A No.

Q What is the next step? What is the next step after putting C bar and the I bar together with the shim in-between?

A Putting the glass rod in.

Q And is that just laid in position there?

A Yes.

Q Do you attempt to put it in position adjacent the gap then existing between the C bar and the I bar?

A Say that once more.

Q Do you place the glass rod adjacent to the space between the C bar and the I bar?

A Yes.

Q Is it held in position there?

A Yes.

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Q How?

A With Duco cement.

Q What is the next step after that?

A It is put or placed in the bonding kiln.

Q How is it held together while it is being put into the bonding kiln?

A With Duco cement.

Q Does Duco cement hold the C bar to the I bar also?

A Yes.

Q Where is the cement applied?

A On the outer edges.

Q All around?

A Just spots.

Q Does that mean on the edges of the lengthwise portions or also on the ends?

A On the ends.

Q So the assembly is essentially held together by cement at that time?

A Right.

Q It is then put into the bonding kiln?

A Right.

Q And what is done to it then?

A A load is applied.

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Q Is that a weight?

A Yes.

Q What is the next step?

A Then the temperature in the kiln -- the kiln is brought up to temperature and the glass is capillary flowed into the gap.

Q What happens to the Duco cement during that heating?

A It burns off.

Q Just vaporizes?

A Oxidize -- yes, sir.

Q It disappears?

A Yes.

Q During that process, is the gap filled entirely with glass?

A Yes.

Q Does the glass then mechanically join together the two bars?

A Yes.

Q And it bonds to them, isn't that so?

A Right.

Q Right?

A Yes.

Q Is there any other bonding agent than the

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glass?

A No.

Q You have shown in this diagram a relatively narrow gap near the edge of the two bars and on the inner edge where the glass rod was placed, there is a flaring space.

After the bonding is completed, is there glass in that flaring space to which I have referred?

A Yes.

Q What temperature was used in the kiln?

A It depends on the glass that is used.

Q Each glass has its own temperature?

A Yes.

Q And what ranges of temperature have you experienced in your work?

MR. JUDLOWE: At IBM.

A As low as 350 degrees C up to 900 degrees C.

Q But in each instance, the glass has softened enough to flow?

A Yes.

Q Do you have knowledge as to the nature of the ferrite material used at IBM?

A No.

Q How do you identify any particular material;

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same number?

A By number.

Q But you don't know the composition of it?

A No.

Q Do you know how it is made?

A Just a rough idea, that's all. I never was involved in it.

Q Is it made by sintering from a powder?

A I believe that's part of the operation.

Q Do you know the nature of the glass that was used?

A No, that was made in a different department.

Q You were supplied with the glass in the form of the rods that you assembled?

A Right.

Q Before the C bar and the I bar are bonded together, are the gap surfaces polished?

A Yes.

Q Is that part of the machining that you referred to?

A All included.

Q When the glass is flowed between the bars, does the ferrite material melt?

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A Repeat that, please.

MR. RELSON: Would you read that.

(Question read)

A No.

Q Does the glass melt?

A Yes.

Q Has IBM issued specifications for the heads and the materials that go into the heads?

A Specifications? Repeat that, please.

MR. RELSON: Read it back.

(Question read back)

A At the time I was there, they were, yes.

Q And you were acquainted with those specifications?

A Yes.

Q Do you have a copy of those specifications?

A No.

Q Do you know of any copy at Micronetics?

A No.

Q As best you can recall, what did those specifications say as to the types of materials to be used?

A At the time I was there making recording heads, we only used one type of material.

Q What was that?

A Nickel zinc.

Q You mean a nickel zinc ferrite?

A Right.

Q And so far as know, you always used the same material?

A Right.

Q What did the specifications say as to the nature of the glass to be used?

A I don't recall the specifications on glasses. I do not recall any specifications called out for glasses to be used.

Q Did the specifications indicate any relationship between the properties of the glass and of the ferrite?

A Yes.

Q What was that relationship?

A That the coefficient of thermal expansion be matched within some percentage.

Q Do you know what percentage?

A No, I don't.

Q Why did you leave IBM?

A I was approached by Micronetics.

Q Were you approached because of your experience

PLAINTIFF'S EXHIBIT 220-3



with respect to glass bonded heads?

A Yes.

Q And you were offered a job by Micronetics?

A Yes.

Q And it was an offer you could not refuse, I suppose?

A Well, I was satisfied.

Q In what products does IBM use the glass bonded heads?

A All of their computers.

Q Do they use them on disc memory files?

A Yes.

Q Do they use it on the type 2314 disc memory system?

A Yes.

Q And in others as well?

A Yes.

Q Which is the most prevalent use of heads? That is, in which product are most heads used so far as you know?

A To my knowledge, the 2314.

Q Do you know of any other IBM products using glass bonded heads?

A I believe there are several. If you could define

that question a little --

Q Can you identify any of those products for us by number or otherwise?

A Only by names that I have heard since I have left there. When I left, there were only -- 2314 was the major one.

Q What are the other names that you have heard?

A 3330. There is one they just released in Winchester and that's --

Q How do you identify that one?

A I don't have any identity. I have not even read an article on it.

Q What type of product is the 3330?

A What do you mean by what type of product?

Q You said you knew of a 3330 product. What is the general nature of that product? Is it a disc memory system or is it something different?

A It is a disc memory system, yes.

Q And one that uses recording heads?

A Right.

Q Does it use recording heads of the same type as the ones that you have been testifying about

A Basically, the same type, yes.

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Q Made in the same way?

A Pardon?

Q Made in the same way?

A Yes.

Q That is, they are made with the use of this capillary action?

A I assume so.

MR. JUDLOWE: Mr. Relson, before we leave IBM, and I thought you were doing this a moment ago, I would like that drawing marked as an exhibit.

MR. RELSON: Oh, certainly. Let's have the diagram marked as Plaintiff's Deposition Exhibit 13.

(Diagram marked Plaintiff's Exhibit No. 13 for identification, this date.)

Q While you were at IBM, did you have any experience in making recording heads in any other way than by glass bonding?

A No.

Q In making the heads at IBM, were the bars, the C bar and the I bar, passed through a heating and cooling cycle before they were assembled with the spacer and the glass rod?

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A No. No.

Q That is, after the machining --

A Right.

Q You assembled them immediately with the spacers and the rods without any intermediate heat treating?

A Right.

Q Let me complete a few other aspects of the IBM procedure.

After the kiln operation in which the glass is flowed into the gap, how are the individual elements for the heads fabricated?

A They are -- the bonded assembly is sliced in two directions; one to separate the halves and then to slice individual cores from those halves.

Q Taking the first slicing to slice it into two halves, I think you said; is that right?

A It can be done two ways, right.

Q Where is that slicing done? And could you indicate that on the drawing?

(Witness indicating)

You are adding a dotted line?

A Yes.

Q Would you just mark that slicing line

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or whatever term you use?

A Yes. (Indicating)

Q You have marked that "slice;" is that right?

A Yes.

Q So you cut the bonded bars essentially in half down the center longitudinally; is that it?

A Yes.

Q Then after that, what is done?

A I am going to add more dotted lines. Each section is then cut in that fashion. (Indicating)

Q Then you cut off thin slices from each of the halves?

A Right.

Q Perpendicular to the first slicing line; is that it?

A Right.

Q Before the slicing takes place, is there any machining or grinding or polishing or lapping that is done?

A In some cases, yes.

Q Would you explain the type of operation that is performed in those cases?

A Mismatch is ground from the two bars. That's it.

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Q And where is that grinding done?

A On this surface and this surface. (Indicating on diagram)

Q But on the original longitudinal sides of the bonded bars?

A Yes.

Q And you have placed an X in two positions on the drawing to show that; is that right?

Q If a slice, a transverse slice is made at a position where a shim exists, is that a usable slice?

A No.

Q Those are discarded?

A Right.

Q So the slices between the shims form the usable components?

A Right.

Q While you were at IBM, was the glass rod ever placed in a groove formed in one of the bars instead of being Duco cemented, as you have testified?

(Continued on next page)

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A Yes.

Q Where was such a groove located?

A It could be in the C bar which is on top.

Q In the gap surface itself?

A Yes.

Q Since this is an alternate arrangement, I will ask you to sketch the C bar and the groove in it.

(Witness sketching)

Would you just label the grooves?

A Yes.

(Witness labeling)

Q In the sketch that you have just made, the C bar is turned upside down with respect to the first sketch, Exhibit 13, right?

A Yes.

MR. RELSON: I will ask that the second sketch be marked as Exhibit 14.

(Second sketch marked Plaintiff's Exhibit No. 14 for identification, this date.)

Q In using the type of C bar shown in Exhibit 14, how was the assembly made prior to inserting in the kiln and how was the glass rod put into the assembly?

A It would be the same as Exhibit A with the

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exception of the glass being in the slot instead of in the filler.

Q Was the glass held in position by Duco cement?

A No.

Q That is not necessary then?

A No.

Q Were the two bars, the C bar and the I bar, held together by Duco cement?

A Yes.

Q Were the spacers applied in the same way?

A Yes.

Q When the assembly was put into the kiln, did the glass flow from the grooves into the space in the gap?

A Yes.

Q Did the grooves remain in the slice that was later taken off in those components intended for use?

A No.

Q How was it eliminated?

A Ground off.

Q During this grinding of the longitudinal sides that you mentioned before?

A Yes.

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Q When you joined Micronetics in June of 1969, about how many other employees were there?

A I believe there were eleven or twelve at that time.

Q Were there other employees who were experienced in the production of glass bonded recording heads?

A Yes.

Q And who were they?

A John Moon.

Q He had preceded you?

A Yes.

Q Anybody else?

A No.

Q Had he been at IBM also?

A Yes.

Q To whom did you report when you first went to work at Micronetics?

A Harry Bubnack.

Q What was his position then?

A Secretary of the company.

Q Did he give you your work assignments?

A Yes.

Q You did not report to John Moon?

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A No.

Q Who do you report to now?

A John Moon.

Q When did that change take place?

A The end of last year, the end of '72.

Q Until the end of '72, did you continue to report to Mr. Bubnack?

A No.

Q Whom did you report to in the interim?

A Pat Rivelli.

Q And about when did you begin reporting to him?

A December of '69.

Q What was his position while you reported to him?

A Treasurer of the company.

Q Was he in charge of the development of products?

A Yes.

Q Would you explain to us generally what kind of work you have performed for Micronetics since you joined them?

A I started in production and training people, buying equipment, setting up processes. Then when I

PLAINTIFF'S EXHIBIT 220-3



went with Pat Rivelli, it was prototypes. I have been working on that ever since.

Q At the time you started, what production equipment was available at Micronetics?

A One grinding machine.

Q Hardly enough to make heads, right?

A Right.

Q And you helped them select and acquire the necessary equipment?

A Yes.

Q What were your instructions with respect to setting up processes?

A To build recording heads.

Q In any particular way?

A Right.

Q What particular way?

A The way we knew from IBM.

Q That is, to build recording heads as good as IBM's; is that it?

A Right.

Q Did you follow the same processes you had used at IBM?

A Basically, yes.

Q What changes did you inject over the

PLAINTIFF'S EXHIBIT 220-3



IBM process that you described to us?

A They were the same processes; just we didn't have the capital to work with. So we had make shift. The basic process was the same; possibly a different type of machine versus what they used. The basic process was the same.

Q When you referred to machine, do you mean the kiln or the grinding machines or the machine --

A Polishing.

Q Were you the one who determined what processes would be used by Micronetics?

A Not alone.

Q With whom?

A John Moon.

Q Between the two of you, you evolved the processes that are now in use at Micronetics?

A Yes. And a third, Lionel Bishop.

Q Lionel Bishop also aided you in this?

A Yes.

Q When did he come with the company?

A December of '69.

Q What has been his position?

A He took over my job, production manager.

Q You were production manager initially?

PLAINTIFF'S EXHIBIT 220-3



A Yes.

Q How long did you continue as production manager?

A Did I?

Q Yes.

A Just until Mr. Bishop joined us.

Q And that was when you transferred over to work under Mr. Rivelli?

A Right.

Q You have described for us two different processes, slightly different at any rate, illustrated by the diagram of Exhibit 13 and the diagram of Exhibit 14.

Have both of those been used at Micronetics?

A Yes.

Q Has any one of them been used to a much larger extent than the other?

A Yes.

Q Which?

A Exhibit 13.

Q You said you changed your work from that of production manager to working on prototypes?

A Yes.

Q Would you explain what is meant by working

PLAINTIFF'S EXHIBIT 220-11. 2-A

H A R R Y W. B U B N A C K, having been duly sworn, was examined and testified as follows:

MR. RELSON: This deposition is being taken pursuant to notice, the date having been adjourned by stipulation of counsel to the present day. I ask the reporter to mark a copy of the notice as Plaintiff's Deposition Exhibit ~~9~~ 91.

(Copy of notice marked Plaintiff's Deposition Exhibit ~~9~~ 91 for identification, this date.)

EXAMINATION BY
MR. RELSON:

Q Mr. Bubnack, would you outline for us your

PLAINTIFF'S EXHIBIT 220-11



technical education?

A I am a ceramics engineer, Alfred University, 1958.

Q What degree were you awarded?

A Bachelor of Science and Ceramic engineering.

Q Will you outline for us your industrial, commercial experience?

A Well, my first year, my first job out of Alfred University was with General Refractories Corporation located in Joliet, Illinois, and I was basically a ceramic engineer. I worked there for about a year and a half.

Q Until what date?

A June 1960, at which time I joined Ferroxcube, as a development engineer, development and ceramic engineer. And my primary responsibility was to make glass pre-forms, set up a facility to make glass pre-forms, develop and manufacture glass preforms.

Q How long did you continue at Ferroxcube?

A I was there from 1960 to 1967.

Q Where did you go from there?

A I left in 1967 and I went to ~~Crystinel~~ Corporation in Portchester, New York. I was there for one year.

In 1968, I joined Alloys Unlimited --

Q Is that Alloys Unlimited?

PLAINTIFF'S EXHIBIT 220-11



A Unlimited -- as a product manager in their Frenchtown CFI division, New Jersey. I was there for about one year also.

Q After that?

A During April 1969 I was one of the four founders of Micronetics. I have been with Micronetics since April 1969.

Q You stated you have a BS in ceramic ~~engineer~~.

Is that a common degree?

A A Bachelor of Science in Ceramic Engineering?

Q Yes.

A I think it's common, yes.

Q Does Alfred University specialize in ceramic engineering?

A Right.

Q What --

A No, THE college of ceramics specializes in ceramic engineering. It's a liberal arts college -- university, I mean, but it has a state school specializing in ceramics.

Q What is the relationship between the New York College of Ceramic and Alfred University?

A It's on the same campus and I think the State College is funded by the State.

PLAINTIFF'S EXHIBIT 220-11



Q Next to the problem of maintaining tolerances, what was the largest problem in attaining improved yields?

A I would say specifically that it's a matter of training people, and being able to make something in volume. I think it's a manufacturing capability rather than a specific process capability. It's a matter of discipline, organization, etcetera, etcetera.

Q During your tenure at Micronetics, what have been your various responsibilities?

A Well, I have done many things there. We have a very informal organization at times. Initially, I started in manufacturing, then for a period of time I was responsible for the engineering, and I was back to manufacturing again, and then in March of this year I was named general manager of the Micronetics division.

Q That would be last March?

A This past March, '74.

Q What division?

A Well, we have three separate operating divisions in the corporation now.

Q What are they?

A With the Micronetics division, there are separate

PLAINTIFF'S EXHIBIT 220-11



Q You said there was only one way to make cores.

What is that way?

A Well, what kind of cores are you talking about?

A Glass bonded cores, of course.

A Well, you obviously got to get glass in there some way, and the only way ~~in~~ OF getting it through there is by letting it ~~fall~~ FLOWING in there. Being a ceramics engineer and being involved in the materials, that's the only way you can probably do it, the only way, especially with a very, very small gap. There is no other way you can do. By some mechanism you have got to get glass in there, it has to ~~fall~~ FLOWING in there.

Q You are not aware of any other way of having the glass located in the gap?

A I am not,I know of no other way.

Q You spoke of being involved in making glass preforms; is that correct?

A Yes.

Q Are those preforms used to join together two pieces of metal?

A Basically, yes. It's the art of glass-to-metal

PLAINTIFF'S EXHIBIT 220-11
Bubnack



sealing is one we have a metal ring with metal leads coming to the assembly, and you place the glass around these rings, around the leads, through the leads, and inside the ring, and the glass goes through a furnace, goes through a wetting action, adheres to the leads and the outer ring.

Q That glass is positioned between the two parts to be joined before the heating takes place, is that correct?

A Yes. But during the heating it obviously just wets.

Q Wasn't it possible to use a similar preform in making glass bonded cores?

A I don't know. Idon't know.

Q You do not know.

A I don't see how you can do it. Iam not ~~the~~ a NP technical genius, but --

Q What makes it impossible in your view?

A I think controlling the gap would be very difficult doing it any other way but that.

Q Would it be possible to do it if the gap were not controlled?

A It's possible to do anything ~~together~~. Glue it together, put it together any way without any degree

PLAINTIFF'S EXHIBIT 220-11
Bubnack



of tolerances. It is possible, sure.

Q So when you said this is the only way to make cores you were implicitly limiting that to cores having the size gap and the kind of tolerances to produce the kind of yields that you wanted, isn't that correct?

A Just limit it to the kind of cores we had to make, yes. You can't make any other kind of cores, ferrite glass bonded recording cores, as far as I know, in any other process other than allowing the glass to ~~fall~~ flow through there. There may be other ways, but I don't know of any.

Q Is it your opinion that it could not be done by positioning the glass betwen the gap faces in advance, is that right?

A No, I don't think it can be done.

Q The reason it cannot be done is that you could not maintain the gap length, as I understand your testimony, is that correct?

A Gap length I would think is a prime reason, yes.

Q So when you say it could not be done, were you saying it could not be done within the tolerances

PLAINTIFF'S EXHIBIT 220-11



required?

A Right.

Q You are not saying it was a physical impossibility to do it, were you?

A I don't think if you want to make a gap an inch long, obviously plus or minus a half inch tolerance, you can put two pieces of glass and squash it together. Yes.

MR. JUDLOWE: It is five after twelve, I would like to make some kind of arrangement for lunch, I would like to know what is your pleasure.

MR. RELSON: I would say ten or fifteen minutes.

Q Is it the gist of your testimony that it would be impractical to produce glass bonded cores by any other process?

A I would say that is true, yes. The kind of product we are making, yes.

Q Are you acquainted with the subject matter of the patents in suit?

A I haven't read the patents entirely. No, I am acquainted with them, but not intimately.

PLAINTIFF'S EXHIBIT 220-11
Bubnack



of them might be within specified tolerances and others not?

A Not within the same bar.

Q Within the same bar you would find them within the range of normal tolerance specification?

A Yes.

Q What ranges of tolerance specification have you met up with at Micronetics?

MR. JUDLOWE: I want to understand that question. Do you mean customer requirements, or what does the process do? What specification or ranges are you talking about?

Q Specifications or ranges either of customers or as specified by Micronetics.

A Gap lengths we hold pretty close. We have customers that want plus or minus ten microinches, we have customers who want plus or minus five microinches.

Q That would be a gap of approximately 100 microinches?

A Yes, approximately.

Q What kinds of tolerances were specified in the order of fifty microinches?

A Plus or minus five, plus or minus ten.

Q What about for larger gap lengths?

A Plus or minus 20, plus or minus 30.

Q For what nominal gap lengths would those tolerances apply?

A Generally larger ones, over about 200 microinches. Or larger.

Q Have you had gap lengths as large as four to five hundred microinches?

A I think so, yes.

Q What tolerances have been specified for them?

A I don't know.

Q As high as plus or minus fifty microinches?

A I am not sure.

Q How precisely can a gap length be measured at Micronetics?

A In which form?

Q In any form.

A Plus or minus a couple of microinches.

Q Meaning three or four?

A Within that, within it, I would think. Within two or three microinches. Not plus or minus two or three microinches, within two or three microinches.

Q Well, when you come up with a measured value, how precise is that fact?

511a

PLAINTIFF'S EXHIBIT 248.

April 2, 1968 J. E. VISSER ET AL 3,375,575

HEAT AND PRESSURE GLASS BONDING OF SPACED MAGNETIC HEAD PORTIONS BY FORMING AND USING GLASS OVER FLOW CHANNELS

Filed May 6, 1963

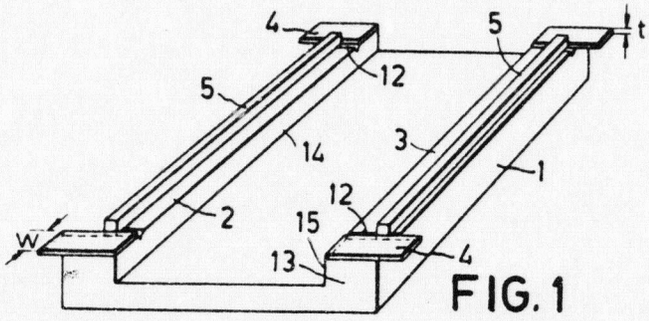


FIG. 1

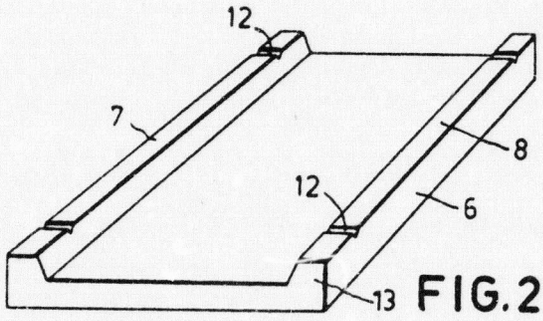


FIG. 2

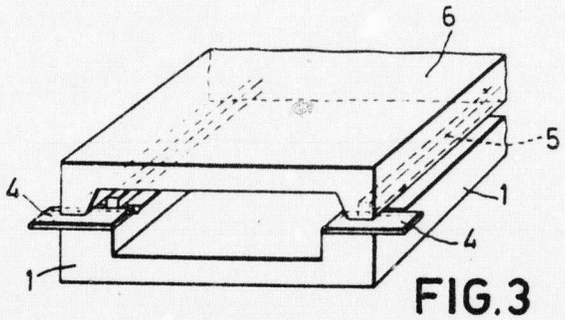


FIG. 3

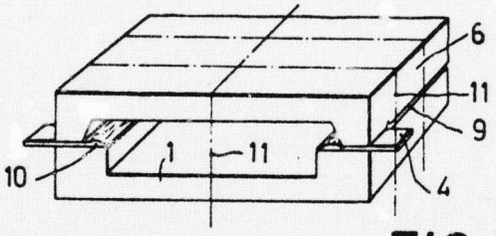


FIG. 4

PLAINTIFF'S EXHIBIT 248-id

U. S. Philips Corp. vs. National Micronetics, Inc. C. A. 71 Civ. 921 R. W.

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AGENT

PLAINTIFF'S EXHIBIT 248

United States Patent Office

3,375,575

Patented Apr. 2, 1968



3,375,575

# HEAT AND PRESSURE GLASS BONDING OF SPACED MAGNETIC HEAD PORTIONS BY FORMING AND USING GLASS OVER FLOW CHANNELS

Jan Erik Visser and Matthijs Henricus Maria Vrolijks, Emmasingel, Eindhoven, Netherlands, assignors to North American Philips Company, Inc., New York, N.Y., a corporation of Delaware

Filed May 6, 1963, Ser. No. 278,012
Claims priority, application Netherlands, May 4, 1962, 278,093
1 Claim. (Cl. 29—603)

This invention is concerned with magnetic heads having bonding glass gap spacers and with methods of manufacturing such heads.

This type of magnetic head, in which sintered oxidic ferromagnetic material (ferrite) is used as the magnetic material, is especially useful when heads having very short gap lengths are desired. One method of manufacturing these heads is shown, for example, in United States Patent 3,024,318, assigned to the assignee of the instant application. The method described in this patent consists of interposing a glass foil between the polished ferrite gap surfaces, the thickness of the foil exceeding slightly the ultimately desired gap length, heating the assembly thus formed to a temperature lying in the softening range of the glass and compressing the assembly at a temperature lying in the softening range under a pressure such that, after hardening of the glass, the correct gap length is achieved.

A problem sometimes encountered when manufacturing magnetic heads with glass gap spacers is that air bubbles occur in the glass. This is of course undesirable since it is obvious that the bonding strength is thereby reduced and, in addition, the ferrite gap edges may be insufficiently supported, with the consequence that the gap edges tend to crumble away.

The primary object of the invention is to provide a method for manufacturing magnetic heads having bonding glass gap spacers in which the glass is more homogeneous and does not contain air bubbles.

Another object of the invention is to provide a relatively simple and easily performed method of manufacturing heads of the above type which yields heads having good mechanical and magnetic properties.

The above and further objects of the invention, together with the various features thereof, will be best understood from a consideration of the description below, taken in conjunction with the accompanying drawing, wherein:

FIG. 1 shows one magnetic circuit part of sintered oxidic ferromagnetic material (ferrite);

FIG. 2 shows a second circuit part of the same material adapted to co-act with the part of FIG. 1;

FIG. 3 shows the parts of FIGS. 1 and 2 placed in co-acting relationship with each other, before heating; and

FIG. 4 shows the parts of FIG. 3 in position after heating under pressure.

Referring now to the drawing, wherein like reference numerals denote like parts, reference numeral **1** denotes generally a magnetic circuit part composed of a sintered oxidic ferromagnetic material. The circuit part **1** is shown in the figures as U-shaped but the invention is not restricted thereto and any convenient shape may be chosen. Circuit part **1** has end faces **13** and upstanding legs **14** and **15**. The legs **14** and **15** are provided with gap surfaces **2** and **3** which, in the assembled head, co-act with similar surfaces on a second magnetic circuit part, shown generally as reference numeral **6** in the figures.

The surfaces **2** and **3** should be ground flat and polished; spacing members **4**, having a thickness *t* equal to the desired gap length are placed on the surfaces **2** and **3**, at the ends thereof, preferably flush with the end surfaces **13**, as shown in FIG. 1. The spacing members may be made, for example, of beryllium copper, mica or any other suitable non-magnetic material. The width *w* of each spacing member is not critical and may be given any convenient value approximating the relative proportions shown in the figure. Glass rods **5** are then placed on the surfaces **2** and **3** as shown, each rod being located between the spacers **4** also located on the particular surface. While the glass rods are shown as rectangular in FIG. 1, they may be of any other convenient shape as long as the smallest cross-section of the rod is greater than the thickness *t* of the spacing member, i.e., the body portions of the rods should extend up beyond the top faces of the spacers.



After the spacers **4** and the glass rods **5** are in place on the surfaces **2** and **3**, a second circuit part **6**, also composed of sintered ferromagnetic oxide material, substantially corresponding in shape with circuit part **1** and having flat and polished surfaces **7** and **8**, is placed on the part **1** in a manner as shown in FIG. 3, i.e., with corresponding surfaces **2**, **7** and **3**, **8** facing each other separated by glass rods **5**. As can be seen, the surfaces **7** and **8** rest on the glass rods.

Prior to placing the two circuit parts adjacent to each other as in FIG. 3, small cross grooves **12** may be sawed in the polished surfaces **7** and **8**. Also, cross grooves **12** could be sawed in surfaces **2** and **3** prior to placing spacers **4** and rods **5** thereon. If cross grooves **12** are provided, it is most advantageous if the distance from each cross groove **12** to the closest adjacent end face **13** be equal to the width *w* of the associated spacer **5**. This configuration is the one shown in the drawing. The purpose of the cross grooves is more fully set forth below.

Subsequent to the operation of FIG. 3, the assembly thus formed is heated under pressure to a temperature such that the glass melts and begins to flow. When this occurs, the circuit parts **1** and **6** move closer together, until the spacing members **4** prevent further movement. The assembly is then cooled. The gaps **9** appearing between surfaces **2**, **7** and **3**, **8** are thus filled with glass which bonds the two circuit parts together, each gap having a length equal to the thickness of the spacing members **4**. Further, the glass has been found to be homogeneous in composition and to contain no air bubbles. This is due to the fact that, when pressure is applied, the melted glass flows outwardly from approximately the center of the gap surfaces to both edges thereof. Therefore, air or other gases which might otherwise be trapped in the glass are forced away from the glass and the bounding gap surfaces. If the volume of each glass rod is larger than the volume of the ultimately desired gap, a quantity of excess glass will be formed and this excess glass, after solidification, appears for the greater part on the inside of the gap, designated by reference numeral **10** in FIG. 4; this excess contributes to the strengthening of the bond. It has been found that it is most efficaceous if the volume of each glass rod **5** is at least 30 percent larger than the volume of the ultimately desired gap.

The grooves **12** serve to ensure that no excess glass penetrates between a spacing member and one of the surfaces **2**, **3**, **7** or **8**. If such penetration occurred, the gap length would be longer than that desired and predetermined by the thickness *t* of the spacing members.

The assembly shown in FIG. 4 may be divided, for example by sawing, along the axis **11**, thus providing a plurality of annular magnetic head portions including gaps, to which further portions, such as a yoke and windings, may be attached, to provide a complete head. Such attachment, which may be done by conventional means, forms

PLAINTIFF'S EXHIBIT 248





no part of the instant invention and is therefore not shown.

While the invention has been described with respect to a specific embodiment, various modification thereof will be apparent to those skilled in the art without departing from the inventive concept, the scope of which is set forth in the appended claims.

What we claim is:

1. A method of manufacturing parts of glass bonded magnetic heads composed of two circuit parts consisting of sintered oxidic ferromagnetic material and having gap surfaces with a gap therebetween filled with glass bonding the circuit parts together, comprising: forming first and second over-flow channel cross grooves adjacent first and second ends respectively of at least one of said circuit part gap surfaces, placing spacing members having a thickness equal to the desired gap length at opposite ends of a polished gap surface of said one circuit part, said spacing members each occupying that respective area of said gap surface between the end thereof and a respective one of said cross grooves, said gap surface having a predetermined area, placing a glass rod on said gap surface between said spacing members, said glass rod having a volume larger than the volume of the ultimately desired gap, the surface of said glass rod placed on said gap surface having an area substantially less than said predetermined area, the smallest cross-section of said glass rod being greater than the thickness of said spacing members, placing a corresponding polished gap surface of a second circuit part on said glass rod, heating the resulting assembly under pressure to melt the glass and form a gap having a length equal to the thickness of said spacing members, each of said cross grooves forming a flow channel for said molten glass to prevent said molten glass from disturbing the position of said spacing members, and cooling said assembly to allow said glass to bond the circuit parts together.




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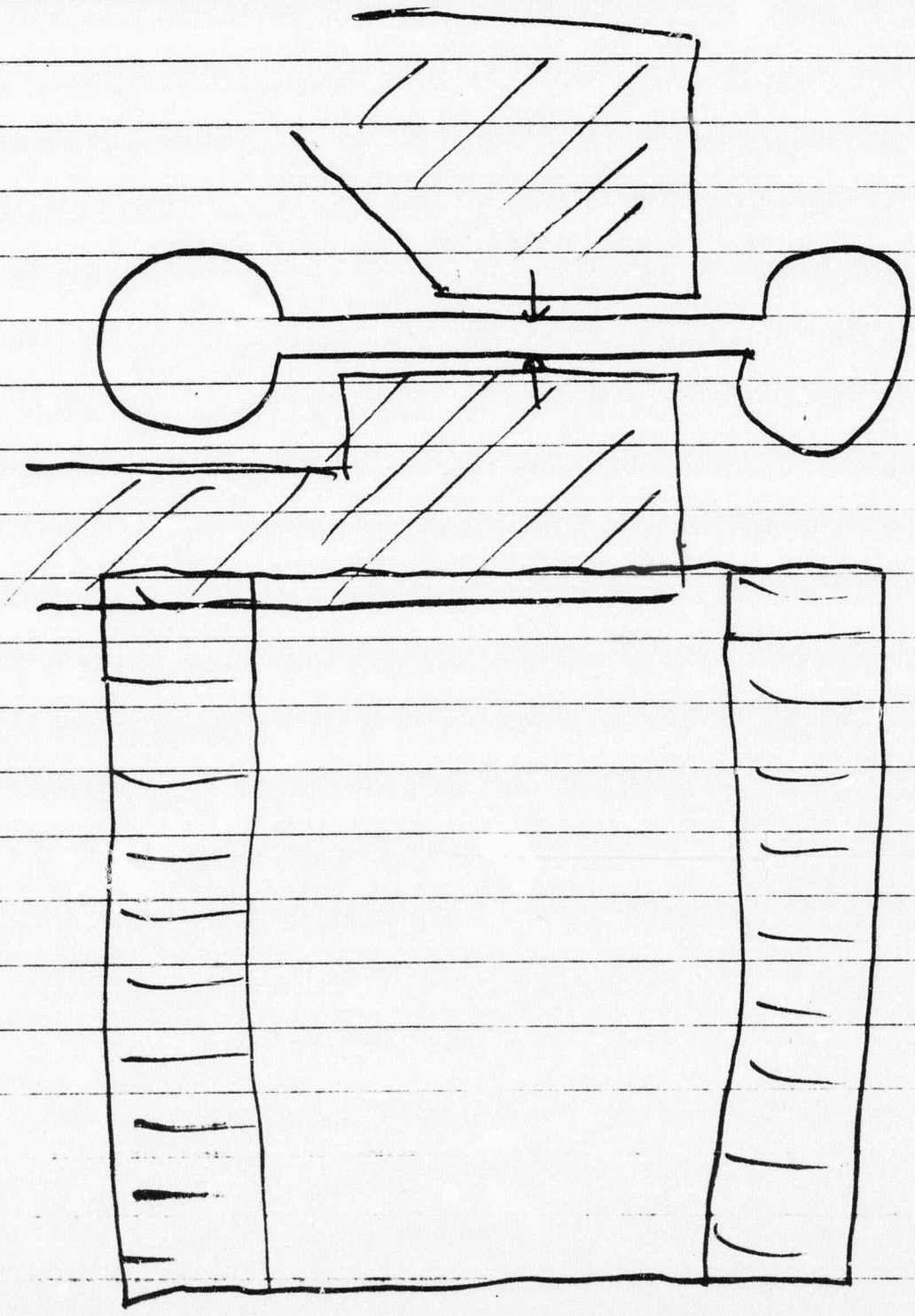
JOHN F. CAMPBELL, *Primary Examiner.*

J. W. BOCK, R. W. CHURCH, *Assistant Examiners.*

PLAINTIFF'S EXHIBIT 249.

Vrobyks Sketch on blackboard



DEFENDANTS' EXHIBIT G.

March 14, 1950 E. T. GRANT 2,500,748

MAGNETIC STRUCTURE

Filed Nov. 21, 1947

Fig 1.

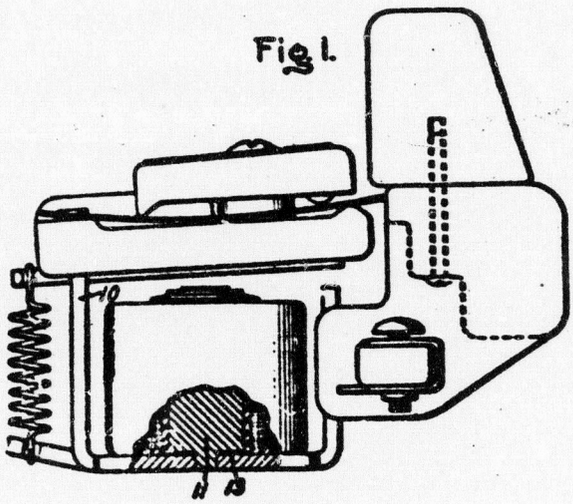


Fig 2.

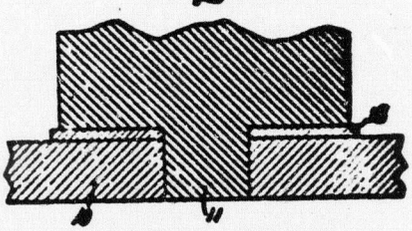
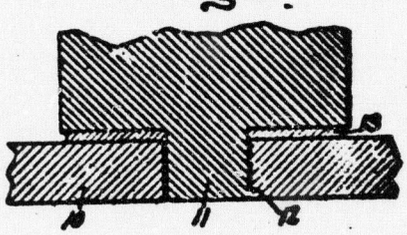


Fig. 3.



Inventor:
Eduard T. Grant.
by Frank T. Mac
His Attorney

Patented Mar. 14, 1950



2,500,748

DEFENDANTS' EXHIBIT G

# UNITED STATES PATENT OFFICE

2,500,748

## MAGNETIC STRUCTURE

Edsard T. Grant, Scotia, N. Y., assignor to General Electric Company, a corporation of New York

Application November 21, 1947, Serial No. 787,433

2 Claims. (Cl. 175—21)

1

My invention relates to magnetic structures, and more particularly to a method and means for joining together two or more magnetizable members to form a unitary magnetic structure.

It is a general object of my invention to provide a new and improved magnetic structure which is simple and inexpensive in manufacture, and durable and reliable in operation.

It is a further object of my invention to provide a new and reliable method of making magnetic structures having permanent and predictable characteristics.

It is a more specific object of my invention to provide a new and improved method and means for joining together two or more parts of a magnetic structure, while providing therebetween a permanent non-magnetic gap of fixed dimension.

In accordance with my invention, I provide a magnetic structure comprising a pair of magnetizable members having contiguous surfaces brazed together to form a joint. In forming the joint, I first position adjacent the contiguous surfaces a body of low melting point non-magnetizable brazing material, such as copper or the like. With the parts thus assembled, I braze the joint to form a unitary structure, the brazing operation introducing by capillary action a film of non-magnetizable material between the contiguous surfaces of the joint, thereby to form a permanent non-magnetic gap of fixed dimension in the magnetic structure.

My invention will be more fully understood and its various objects and advantages further appreciated by referring now to the following detailed specification taken in conjunction with the accompanying drawing, in which Fig. 1 is a side view, partly in section, of an electromagnetic relay embodying my invention, and Figs. 2 and 3 are enlarged cross sectional views showing successive steps in the formation of a brazed joint between the two magnetizable frame members of the relay.

Referring now to the drawing, and particularly to Fig. 1, the electromagnetic relay there shown by way of illustration of my invention, comprises a U-shaped magnetizable frame member 10 having mounted thereon a center leg, or coil core, 11. The core 11 is attached to the bight portion of the U-shaped frame 10 by a mortise and tenon joint having a thin film 12 of non-magnetizable brazing material, such as copper, or the like, interposed between contiguous surfaces of the mortise and the tenon. This brazed joint is shown in greater detail at Fig. 3. This joint is formed by brazing together the jointed portions of the magnetizable

2

frame with copper or other suitable brazing material, in the manner described in greater detail below.

In forming the joint illustrated at Figs. 2 and 3, the magnetizable frame member 10 is mortised to form a tight press fit with the tenon on the member 11. In assembling the members 10 and 11, a thin washer 13 of copper, or other suitable non-magnetizable brazing material is first slipped over the tenon on the member and seated against the shoulder at the base of the tenon. The tenon is then pressed into the mortise member with the non-magnetic washer 13 therebetween. In this assembled position, and prior to the brazing operation, the joint appears as illustrated at Fig. 2 of the drawing.

With the frame members pressed together as shown at Fig. 2 and with the copper washer 13 in position, the structure is heated utilizing the washer 13 as a brazing metal, thereby rigidly to fasten the parts together at the joint. In the brazing operation, the washer 13 is raised to its melting point, and by capillary action a portion of the washer 13 flows along the contiguous surfaces of the mortise and the tenon, as indicated at 12, Fig. 3. This film 12 of brazing material wets the surfaces of the tenon and the mortised member and flows between these surfaces, so that there is no iron-to-iron contact upon completion of the brazing operation. The thin film and sleeve of non-magnetizable material provides a permanent non-magnetic gap of fixed dimension, and serves also to braze the parts rigidly together in the desired position.

In the completed magnetic structure comprising the core 11 and the frame 10, the washer 13, of course, also forms a non-magnetic gap of fixed dimension, since not all the magnetic flux passes through the tenon. In such a structure, the residual magnetic characteristic of the structure depends, in part, upon the relative cross sectional areas of the core and tenon. As the tenon is made larger relative to the core, the residual magnetism increases, for a greater proportion of the flux passes through the tenon and the small capillary gap, so that the net effective gap is less.

While I have shown and described only a preferred embodiment of my invention, by way of illustration, various modifications will occur to those skilled in the art and I, therefore, wish to have it understood that I intend in the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

DEFENDANTS' EXHIBIT G





1. In a magnetic structure, a pair of magnetizable members having a mortise and tenon joint therebetween, a washer of non-magnetizable material brazed between said members adjacent said joint, and a capillary film of said non-magnetizable material brazed between contiguous surfaces of said joint.

2. In a magnetic structure, a first magnetizable member provided with a mortise, a second magnetizable member having a projection thereon forming a tenon, said two magnetizable members being interfitted to form a mortise and tenon joint, a washer of low melting point non-magnetizable material brazed between said members adjacent said joint, and a capillary film of said non-magnetizable material brazed between contiguous surfaces of said mortise and tenon, thereby rigidly to connect said magnetizable members together and to form therebetween a permanent non-magnetic gap of fixed dimensions.

EDUARD T. GRANT.

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DEFENDANTS' EXHIBIT H.

March 6, 1962 S. DUINKER ETAL 3,024,318

GLASS GAP SPACER FOR MAGNETIC HEADS

Filed Sept. 11. 1956

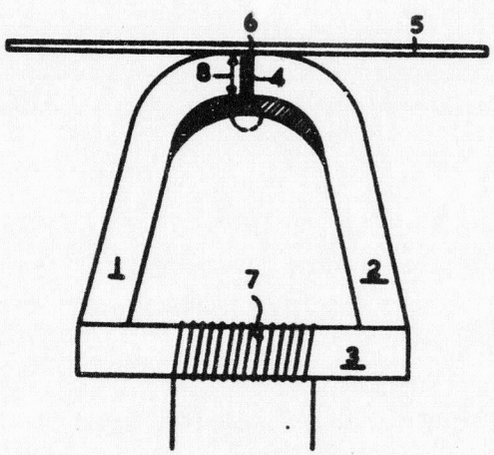


FIG.1

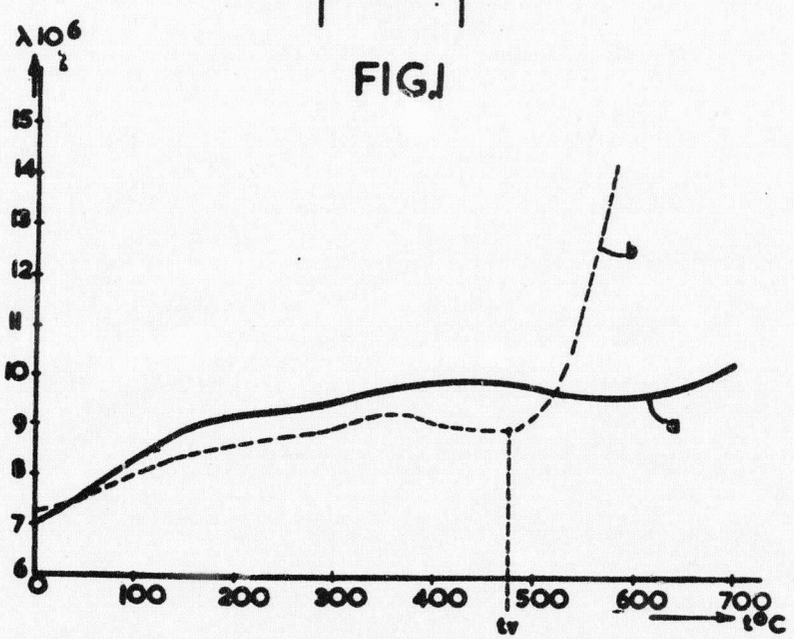


FIG.2

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DEFENDANTS' EXHIBIT H

United States Patent Office

3,024,318

Patented Mar. 6, 1962



3,024,318

# GLASS GAP SPACER FOR MAGNETIC HEADS

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Filed Sept. 11, 1956, Ser. No. 609,284
Claims priority, application Netherlands Oct. 4, 1955
4 Claims. (Cl. 179—100.2)

The present invention relates to annular heads for magnetic recording and/or reproducing apparatus. More particularly, the invention is concerned with such heads which comprise at least two circuit parts of sintered ferromagnetic oxide material between which an effective gap is formed and includes the improvement of filling said gap with glass, the glass serving as nonmagnetic material to protect the effective gap and also to join the two circuit parts to one another mechanically.

The term "annular head for a magnetic recorder" as used herein is to be understood to mean a magnetic recorder head, the circuit parts of which are so shaped that, when assembled, they enclose a central space in which one or more coils can be arranged.

Generally, the non-magnetic material which fills the effective gap, i. e. the gap past which the carrier of the magnetic recordings is guided, consists of a foil-shaped spacing plate made of a non-magnetic metal, for example beryllium copper, the thickness of which fulfils the requirements to be satisfied by the width of the gap. In the present state of the art with respect to magnetic recordings, these requirements have become comparatively exacting and the disadvantages attendant on the use of such distance foils during manufacture are becoming increasingly marked. Even discounting the manufacturing difficulties, however, such plates having a thickness of a few microns are very vulnerable owing to their size and, in addition, any burrs produced on a plate become comparatively significant in ensuring a good connection of the circuit parts.

In order to obviate these disadvantages, it has already been suggested to use as the non-magnetic material synthetic substances which are provided in the liquid state and then are hardened and which also mechanically connect together the two circuit parts. As examples of such materials we may mention ethoxulin resin and poly-ester resin.

Since the material is provided in the liquid state, it is enabled to fill up the space between the surfaces bounding the effective gap, so that a good connection is automatically ensured. In addition, after hardening of the material, the two circuit parts are joined to one another to a certain extent, the ultimate fixation, however, requiring the use of other means, such as pressure discs or lateral springs.

However, the use of these synthetic substances entails a number of disadvantages. The use of further means to ensure the ultimate fixation has already been mentioned. It is also found that the synthetic substances, due to their low heat resistance, are comparatively rapidly worn off during operation, in which a comparatively large amount of heat is generated by the friction between the carrier of the magnetic recordings and the magnetic recorder head, so that the edges of the gap are deprived of the protective action of the non-magnetic material in the gap. It has been found that the unprotected edges of the ferrite are chipped by the wearing action of the magnetic recording carrier. It is also very difficult if not impossible to produce small gap-widths (of the order of magnitude of a few microns and to adjust the desired thickness).

In order to avoid these difficulties, it has been proposed to use glass as the non-magnetic material. Thus part of



the said difficulties, i. e. those with respect to achieving small widths and adjusting the desired thickness, are actually obviated. However, the chipping of the edges of the ferrite is found not to be avoided in the proposed magnetic recorder head.

According to the invention, this last disadvantage is obviated in that as the non-magnetic material use is made of a glass the coefficient of expansion of which, for the temperature at which the magnetic recorder head is used, is equal as far as possible to the corresponding coefficient of expansion of the ferromagnetic material from which the said circuit parts of the magnetic recorder head are made, for example does not differ therefrom by more than 5%.

The invention is based on the recognition of the fact that, even if in the finished product there is a good adherence between the ferromagnetic circuit parts of the magnetic recorder head and the glass, for which adherence a difference in the coefficients of expansion of at least 30% is permissible, the differences in the coefficients of expansion introduce tensions in the glass and in the ferrite owing to which the ferrite edges of the effective gap will show chipping under the action of the mechanical forces exerted by the magnetic recording carrier in operation. It is also found that these tensions give rise to difficulty in manufacture when polishing the pick-up ferrite surface of the magnetic recorder head. Truly flat-ground pick-up surfaces in the proximity of the air-gap are unattainable in practice.

The invention also relates to a method of manufacturing magnetic recorder heads in accordance with the invention. According to the invention, a glass foil is interposed between the polished ferrite gap surfaces which has a coefficient of expansion at the said temperature which is as far as possible equal to that of the ferromagnetic material, the thickness of the foil exceeding the ultimately desired gap-width by a few percents, after which the assembly is heated to a temperature lying in the softening range of the glass and subsequently is compressed at a temperature lying in this softening range under a pressure such that, after hardening of the glass, the correct gap-width is achieved.

Obviously the magnitude and the time of action of the force depend upon the properties of the glass used, upon the cross-sectional area of the magnetic circuit at the effective gap and also upon the temperature at which the force is exerted.

It has been found that, when using sintered ferromagnetic oxide material for the circuit parts of the magnetic recorder head, the glass adherence obtained has a strength which is of the same order of magnitude as that of the circuit parts themselves.

The invention will now be described in detail with reference to the figures of the accompanying drawing, in which:

FIG. 1 shows an annular magnetic recorder head in accordance with the invention, and

FIG. 2 is a curve illustrating the invention.

In FIG. 1, an annular magnetic recorder head comprises two identical circuit parts 1 and 2 and a closing yoke 3. The air-gap 4 formed between the circuit parts 1 and 2 past which the carrier of the magnetic recording 5 is moved, is filled with a non-magnetic material 6, in this case with glass, the coefficient of expansion of which at the above-mentioned temperature is substantially equal to that of the material from which the circuit parts 1, 2 and 3 are made. In the embodiment shown, a coil 7 is provided on the circuit part 3. In the embodiment shown, the glass which is used as the non-magnetic material is not restricted to the air-gap 4, but also fills part of the central space produced by the circuit parts 1, 2 and 3. Such an additional amount of glass imparts an additional rigidity

DEFENDANTS' EXHIBIT H





to the circuit in the vicinity of the air-gap 4 and also enables the height of the air gap designated 8 in the figure to be reduced by grinding to a desirable very small value without the risk of a material decrease of the strength of the circuit in the proximity of the air-gap.

This additional amount of glass can be provided in a simple manner in that, prior to heating, a glass rod of the same kind of glass which is used as the non-magnetic material is arranged at the inner side o fthe ferromagnetic circuit parallel to and in close proximity to the air-gap (this rod is shown diagrammatically in FIG. 1 by a broken circle). During heating, the glass spreads to form a layer as shown in FIG. 1.

An example of a suitable combination is:

FERROMAGNETIC OXIDE MATERIAL

*Composition*

| | Mol percent |
|---|---|
| MnO | 24.1 |
| ZnO | 23.4 |
| FeO | 2.3 |
| $Fe_2O_3$ | 48.8 |
| $SiO_2$ | 1.3 |

Coefficient of expansion: $9.3\times10^{-6}$ between 0° C. and 40° C.

GLASS

*Composition*

| | Percent by weight |
|---|---|
| $SiO_2$ | 56.2 |
| $Na_2O$ | 7.6 |
| $K_2O$ | 4.5 |
| PbO | 30.0 |
| $Al_2O_3$ | 1.2 |
| $Sb_2O_3$ | 0.3 |
| MnO | 0.25 |

Coefficient of expansion: $9.2\times10^{-6}$ between 0° C. and 40° C.

As another example we may mention:

FERROMAGNETIC OXIDE MATERIAL

*Composition*

| | Mol percent |
|---|---|
| NiO | 17.5 |
| ZnO | 33.2 |
| $Fe_2O_3$ | 49.0 |
| $SiO_2$ | 0.3 |

Coefficient of expansion: $7.1\times10^{-6}$ between 0° C. and 40° C.

GLASS

*Composition*

| | Percent by weight |
|---|---|
| $SiO_2$ | 72.5 |
| $Na_2O$ | 11.5 |
| CaO | 10.0 |
| MgO | 3.3 |
| $Al_2O_3$ | 2.5 |
| $K_2O$ | 0.2 |

Coefficient of expansion: $7.3\times10^{-6}$ between 0° C. and 40° C.

Tests have confirmed that, provided the requirement with respect to the coefficient of expansion is satisfied, any other combination of a ferromagnetic oxide material and a glass (for example lime-glass, lead-glass, baryte glass; this latter kind of glass contains from 10% to 30% by weight of BaO) produces satisfactory results. It should be noted that the term "Glass" is used herein in the broadest sense of the word. Compositions which frequently are referred to as enamel or glaze can be used for the desired object. As an example we may mention an enamel of the following composition:

| | Percent by weight |
|---|---|
| PbO | 80 |
| $B_2O_3$ | 16 |
| ZnO | 4 |



Coefficient of expansion: $10.5\times10^{-6}$ between 0° C. and 40° C.

It has been found that an enamel of this composition can be combined satisfactorily with a ferromagnetic oxide material of, for example, the following composition:

| | Mol percent |
|---|---|
| MnO | 30 |
| ZnO | 18 |
| $Fe_2O_3$ | 52 |

Coefficient of expansion: $10.0\times10^{-6}$ between 0° C. and 40° C., or of the following composition:

| | Mol percent |
|---|---|
| MnO | 37 |
| ZnO | 10 |
| $Fe_2O_3$ | 53 |

Coefficient of expansion: $10.2\times10^{-6}$ between 0° C. and 40° C.

However, if the ferromagnetic oxide material of the second example having a coefficient of expansion of $7.1\times10^{-6}$ is combined with the glass of the first example having a coefficient of expansion of $9.2\times10^{-6}$, although a very firm adherence is achieved between the glass and the circuit parts, machining the pick-up ferrite surface proves to give rise to great difficulties, whilst it is also found that, after operation for a few hours, the pick-up ferrite surface of the head is heavily damaged and completely unsuited for further operation.

The same applies to an even higher extent to the combination of the ferromagnetic oxide material of the first example and the glass of the second example.

It has been found that machining the magnetic recorder head, in this case polishing the pick-up ferrite surfaces, is materially facilitated and also that the resistance of the ferrite edges of the effective gap to the mechanical forces exerted by the carrier of the magnetic recordings during operation is improved, if the two coefficients of expansion are as far as possible equal to one another not only at the temperature at which the magnetic recorder head is used, but also over the entire temperature range lying between the temperature at which the magnetic recorder head is used and the temperature at which the glass begins to soften.

When the coefficients of expansion are equal to one another at the temperature at which the magnetic recorder head is used (with a tolerance of 5%), the tensions occurring in the glass are small thus preventing the production of strains in the ferrite which would also tend to facilitate chipping of the ferrite edges of the gap by the mechanical forces exerted by the operation of the magnetic recording carrier; when the coefficients of expansion are equal through the entire above temperature interval (with a tolerance of 10% except at the temperature at which the magnetic recorder head is used) these tensions prove to be substantially entirely eliminated.

FIG. 2 illustrates an example of a suitable combination of materials, the coefficients of expansion of which show satisfactory agreement in the said temperature interval.

In this figure, the (linear) coefficient of expansion of a $\gamma$ sintered ferromagnetic oxide material of the following composition (see the above second example):

| | Mol percent |
|---|---|
| NiO | 17.5 |
| ZnO | 33.2 |
| $Fe_2O_3$ | 49.0 |
| $SiO_2$ | 0.3 |

is plotted as a function of the temperature $t$ in degrees C.

The curve showing the said relationship is designated $a$ in the figure.

In this figure the coefficient of expansion of a line

glass is also plotted as a function of the temperature, the glass having the following composition (see also the above second example):

| | Percent by weight |
|---|---|
| $SiO_2$ | 72.5 |
| $Na_2O$ | 11.5 |
| CaO | 10.0 |
| MgO | 3.3 |
| $Al_2O_3$ | 2.5 |
| $K_2O$ | 0.2 |

The curve showing this relationship is designated *b* in the figure. The temperature at which the glass becomes plastic is indicated by $t_v$. It will be seen from the figure that in the temperature range situated between the temperature at which the magnetic recorder head is used (room temperature) and the temperature at which the glass begins to change its state ($t_v$) the two coefficients of expansion are in very good agreement.

What is claimed is:

1. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising at least two circuit parts of sintered ferromagnetic oxide material with an effective gap between said circuit parts, said gap being filled entirely with a glass material mechanically joining and bonding to each other said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material having a coefficient of expansion substantially equal to the coefficient of expansion of said sintered ferromagnetic oxide material at the temperature at which the magnetic recorder head is used.

2. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising a least two circuit parts of sintered ferromagnetic oxide material with an effective gap between said circuit parts, said gap being filled entirely with a glass material mechanically joining and bonding to each other said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material having a softening temperature, said glass material also having a coefficient of expansion substantially equal to the coefficient of expansion of said sintered ferromagnetic oxide material throughout the entire temperature range lying between the temperature at which the magnetic recorder head is used and the temperature at which the glass begins to soften.

3. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising at least two circuit parts of sintered ferromagnetic oxide material having inner and outer surfaces with an effective gap between said circuit parts, said gap being filled entirely with a glass material mechanically joining and bonding



to each other said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material and said circuit parts forming a closed annular space, part of said glass material extending into said space in contact with the inner surfaces of said ferromagnetic oxide material, said glass material having a coefficient of expansion substantially equal to the coefficient of expansion of said ferromagnetic oxide material at the temperature at which the magnetic recorder head is used.

4. An annular magnetic recorder head for recording or reproducing magnetic recordings comprising at least two circuit parts of sintered ferromagnetic oxide material having inner and outer surfaces with an effective gap between said circuit parts, said gap being filled entirely with a glass material mechanically joining and bonding to each other said circuit parts, said glass material being the sole bonding agent between said circuit parts, said glass material having a softening temperature, said glass material and said circuit parts forming a closed annular space, part of said glass material extending into said space in contact with the inner surfaces of said ferromagnetic oxide material, said glass material having a coefficient of expansion substantially equal to the coefficient of expansion of said ferromagnetic oxide material throughout the entire temperature range lying between the temperature at which the magnetic recorder is used and the temperature at which the glass begins to soften.

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DEFENDANTS' EXHIBIT I.

April 17, 1962 G. REICHENBAUM 3,029,505

METHOD OF ATTACHING A SEMI-CONDUCTOR DEVICE TO A HEAT SINK

Filed Sept. 29, 1958

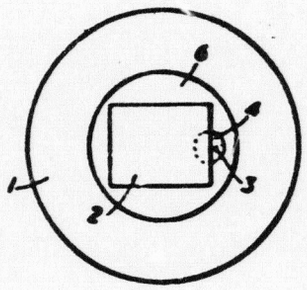


FIG. 1.

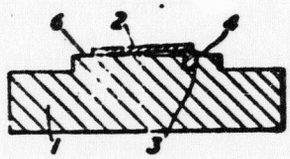


FIG. 2.

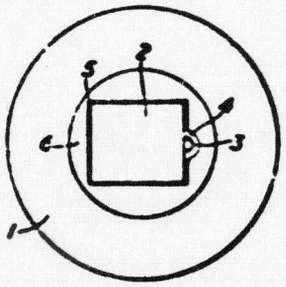


FIG. 3.

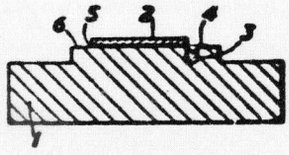


FIG. 4.

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DEFENDANTS' EXHIBIT I

United States Patent Office

3,029,505

Patented Apr. 17, 1962



3,029,505

# METHOD OF ATTACHING A SEMI-CONDUCTOR DEVICE TO A HEAT SINK

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Filed Sept. 29, 1958, Ser. No. 764,125
Claims priority, application Great Britain Oct. 28, 1957
2 Claims. (Cl. 29—501)

This invention relates to semi-conductor devices and more particularly to such devices of the kind in which the device proper—usually a germanium wafer—is fixed to a copper or other base of high thermal conductivity which acts as a heat sink to cool the wafer.

In semi-conductor devices for high powers it is necessary to provide good cooling of the P-N junction to prevent its being damaged by excessive heating. This is usually done by providing a heat sink as near to the junction as possible. The sink is usually in the form of a copper base, sometimes water cooled. It is obviously a requirement that the thermal contact between the sink and the wafer shall be as good as possible and over as large an area as possible. It is by no means easy to satisfy this requirement. Customary present day practice is to insert a sheet of the material known commercially as "Nilo-K" (this is an alloy of Ni, Cu and Fe) between one flat face of the wafer and a flat face of the copper base and then to fire the surfaces together. Nilo-K wets relatively easily but it is of relatively low thermal conductivity and therefore, although it provides a good joint mechanically, the heat transfer it provides between the wafer and the base falls far short of what is desirable.

The present invention seeks to provide an improved method of fixing a semi-conductor device to a heat sink so as to give not only good mechanical attachment, but also to give good heat transfer properties from the said device to the said sink. As will be seen later the method of the invention provides attachment by solder—which is of high thermal conductivity—without the need to employ chemical fluxes with their relatively poor wetting properties and liability to cause corrosion either at the time of use, or later, or both.

According to this invention a semi-conductor device is attached to a heat sink therefor by a method which includes the steps of preparing the device and the sink with surfaces adapted to mate with one another; providing the sink with a small localised reservoir containing a small reserve of solder; placing the mating surface of the device or that of the sink so as to contact with the solder; and firing to cause the solder to flow by capillary action and wet substantially the whole mating surface of the device. In this way, when the solder is allowed to solidify, the result is achieved that the device is soldered to the sink by a thin layer of solder of high conductivity which extends over substantially the whole of the mating surface area. The solder may be fired in the reservoir by a preliminary firing step—preferably effected at a temperature a little lower than that of the main firing step.

Preferably the firing step—or both if there are two—is carried out in a hydrogen atmosphere.

Preferably the reservoir is a small hole in the sink at or near one edge of the mating surface thereof. It assists the even flow of solder between the two mating surfaces to arrange one edge of the mating surface of the semi-conductor device in contact with the solder in the reservoir.

The invention is illustrated and further explained in connection with the accompanying drawings in which FIGURES 1 and 2 are schematic plan and sectional views respectively showing a semi-conductor device on a sink after the firing of solder in a reservoir therein, and



FIGURES 3 and 4 similar views showing the result after a second firing. Like figures denote like parts throughout.

Referring to FIGURES 1 and 2, 1 represents a heat sink constituted by a copper base with a ground flat surface 6 in which is drilled a hole 3 approximately 1/16" deep and of about the same diameter to form a well or reservoir for solder represented at 4. On the base 1 and with its edge in contact with the solder, is a rectangular semi-conducting specimen 2 such, for example, as a germanium wafer, having a flat underface with which the face 6 mates. The solder in the well is fired to the heat sink by a first firing step before the wafer is put in position. Before this firing step the smooth surfaces to be joined are, of course, cleaned carefully, for example by washing the semi-conductor specimen 2 in a mixture of nitric and hydrofluoric acid and immersing the ground surface 6 in nitric acid diluted 3:1 with water, after which a final cleaning of both surfaces in a saturated solution of hydroquinone (a reducing agent) is advantageous. Surfaces thus cleaned can be stored in the clean condition for some considerable time in a fresh solution of hydroquinone. A suitable and satisfactory solder giving excellent wetting is 60/40 eutectic Pb/Sn and the first firing step is preferably accomplished by heating to about 400° C. in a hydrogen atmosphere. The copper heat sink is then cooled and the semi-conductor specimen 2 is placed in position as shown in FIGURES 1 and 2 with the centre of one edge on the pre-fired solder 4. The second firing step is then accomplished again in a hydrogen atmosphere, preferably at a temperature of about 500° C. When the solder has melted sufficiently to allow the semi-conductor layer to fall flat on to the ground surface 6 as shown in FIGURE 4, the solder will start to creep from the well 3 between the two smooth surfaces, due to capillary action. It will also slightly creep up the edges of the specimen 2 as shown at 5 in FIGURES 3 and 4 but will not extend substantially beyond the specimen 2. An addition of approximately 1 mgm. of silver to the solder during the second firing is found to produce better wetting of the surfaces.

In place of the first firing step a plug of solder, long enough to protrude a little from the well, may be placed therein and the protruding solder flattened. The surfaces can then be joined as before by a single firing step (corresponding to the second firing step in the above described process) in a hydrogen atmosphere at about 400° C. The addition of silver in this case is of little or no advantage.

I claim:

1. A method of attaching a semi-conductor device to a heat sink therefor, said method including the steps of preparing the device and the sink with surfaces adapted to mate with one another, forming a well of predetermined size in said sink to act as a receptacle for solder, placing in said well a predetermined quantity of solder, said quantity being the minimum for satisfactory soldering of said device to the sink, the dimensions of said well being predetermined so that said solder extends above the upper edges of said well, the quantity of solder being sufficient to fill the well when molten and provide an excess which is the minimum for satisfactory soldering, shaping the upper surface of said solder so that the device can be positioned thereon, placing the mating surface of the device on the mating surface of the sink so as to contact the solder on one edge, and firing to cause the solder to flow by capillary action and wet substantially the whole mating surface of the device.

2. In a method according to claim 1, placing said device on said sink with one edge of said device resting upon and in contact with the solder extending above the mating surface of said sink, and with the opposite edge

DEFENDANTS' EXHIBIT I





of said device resting upon and in contact with the mating surface of said sink spaced from said solder.


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DEFENDANTS' EXHIBIT J.

June 25, 1963 S. DUINKER 3,094,772

METHOD OF PRODUCING MAGNETIC HEADS WITH ACCURATELY PREDETERMINED GAP HEIGHTS

Filed June 26, 1957

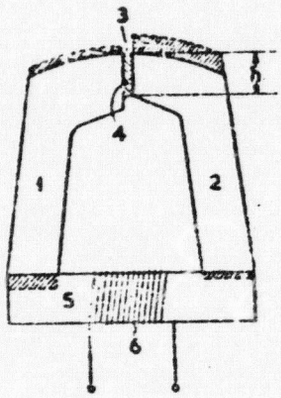


FIG.1

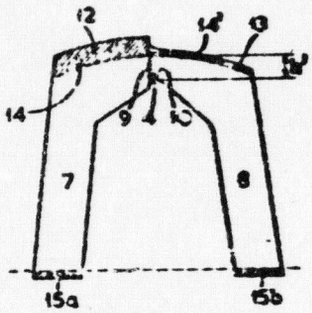


FIG.2

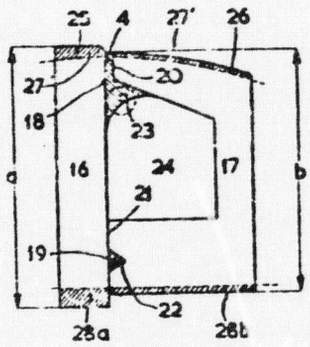


FIG.3

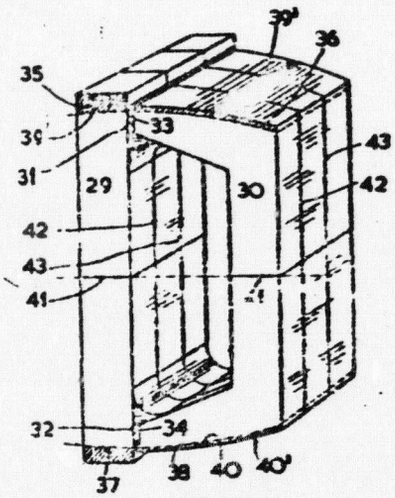


FIG.4

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DEFENDANTS' EXHIBIT J

United States Patent Office

3,094,772

Patented June 25, 1963

1

3,094,772

# METHOD OF PRODUCING MAGNETIC HEADS WITH ACCURATELY PREDETERMINED GAP HEIGHTS

Simon Duinker, Eindhoven, Netherlands, assignor to North American Philips Company, Inc., New York, N.Y., a corporation of Delaware

Filed June 26, 1957, Ser. No. 668,119
Claims priority, application Netherlands July 26, 1956
5 Claims. (Cl. 29—155.59)

This invention relates to a method of manufacturing magnetic recorder and/or reproducer heads for recording or reproducing magnetic recordings, which heads comprise at least two circuit parts of sintered ferromagnetic oxide material, between which an effective gap is formed. The gap is filled with glass which serves as non-magnetic material to protect the gap and which also serves to join the two circuit parts to one another mechanically; the invention also relates to magnetic recorder or reproducer heads manufactured by this method.

When manufacturing magnetic recorder and/or reproducer heads, it is of importance to ensure that the magnetic resistance which the effective gap introduces into the ferromagnetic circuit, is a maximum in order that a maximum part of the magnetic flux, which is produced by the signals which are magnetically recorded on a suitable carrier, flows through the ferromagnetic circuit. To this end, the gap height must be a minimum with a given head width.

However, for a correct determination of the properties of the head and also with a view to the reproducibility, the gap height must also be well-defined.

In U.S. Patent 3,024,318, a method has been described in which initial use is made of two symmetrical component parts, a glass foil being interposed between the accurately finished, for example polished, gap surfaces, the thickness of this foil exceeding the ultimately desired gap width by a few percent, after which the assembly is heated to a temperature lying in the softening range of the glass and subsequently is compressed at a temperature lying in this softening range under a pressure such that, after hardening of the glass, the correct gap width is set.

It has been found in practice that, when use is made of two symmetrical component parts, the accuracy of the ultimately produced gap height is limited by lack of accuracy in the symmetrical arrangement of the two halves, since it should be borne in mind that the relative fixation of the two halves must be effected at temperatures between 500° C. and 1000° C., a molten glass layer being interposed between them.

It is an object of the present invention to obviate this disadvantage and according to the invention, a method of manufacturing magnetic recorded and reproduced heads is characterized in that initial use is made of two component parts which are each provided with at least one accurately finished surface, that these parts are arranged so that the said surfaces engage one another but for the interposition of a glass foil, the thickness of which exceeds the ultimately desired gap length by a few percent, that in the direction of the gap height one surface exceeds the other, that the assembly is heated to a temperature lying in the softening range of the glass and subsequently is compressed at a temperature lying in this

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softening range under a pressure such that, after hardening of the glass, the correct gap length is set. Further, after the assembly has cooled, the guide face of the head is provided by an accurate finishing operation, the determination of the gap height being based on the surface which is smaller in the direction of the gap height.

The prior art method will be explained more fully with reference to FIG. 1 of the accompanying drawings and the method in accordance with the invention will be described more fully with reference to FIGURES 2, 3 and 4 of these drawings.

FIG. 1 is a cross-sectional view of a magnetic recorder or reproducer head manufactured by the prior art method. Reference numerals 1 and 2 designate two circuit parts of sintered ferromagnetic oxide material, between which an effective gap 3 is formed which is filled with glass 4 which serves as non-magnetic material to protect the gap and also to join the two circuit parts to one another mechanically. A closing yoke, which together with the parts 1 and 2 constitutes the ferromagnetic circuit of the magnetic recorder or reproducer head, is designated 5.

In the embodiment shown, a coil 6 is provided on the circuit part 5.

It is assumed that in manufacture initial use is made of two identical parts 1 and 2. The original shapes of these parts and their relative positions after hardening of the glass are shown by broken lines. Subsequently, the shaded parts are removed by grinding, for example by polishing. In spite of the accuracy with which this operation can be performed, the gap height, which is designated by *h*, cannot be determined within narrow limits owing to the uncertainty with respect to the relative position of the two parts, which is not readily controllable.

In addition, the parts 1 and 2 may be twisted with respect to one another and it will be appreciated that this does not make for accuracy in the gap height.

These disadvantages do not occur in the method in accordance with the invention, which will be described more fully with reference to FIG. 2. Initial use is made of two component parts 7 and 8, which are each provided with an accurately finished surface 9 and 10 respectively. Between the surfaces 9 and 10 a glass foil 4 is interposed, the thickness of which exceeds the ultimately desired gap length by a few percent. In the direction of the gap height, the surface 9 exceeds the surface 10. The assembly thus obtained is heated to a temperature lying in the softening range of the glass and compressed at a temperature lying in this softening range under a pressure such that, after hardening of the glass, the correct gap length is set.

Obviously, the magnitude and the time of action of the force depend upon the properties of the glass used, upon the cross-sectional area of the magnetic circuit at the effective gap and also upon the temperature at which the force is exerted.

It has been found that, when using sintered ferromagnetic oxide material for the circuit parts of the magnetic recorder or reproducer head, the glass adherence thus achieved has a strength which is of the same order of magnitude as that of the circuit parts themselves.

It should be noted that preferably glass is used, the coefficient of expansion of which, for the temperature at which the magnetic recorder head is used, is approxi-

mately equal to, for example does not differ by more than 5% from, the coefficient of expansion of the ferromagnetic material, however, preferably use is made of glass, the coefficient of expansion of which, throughout the entire temperature range lying between the temperature at which the magnetic recorder is used and the temperature at which the glass begins to soften, is approximately equal to, for example does not differ by more than 10% from, the coefficient of expansion of the ferromagnetic material.

After the assembly has been sufficiently cooled, a guide face 14 is provided by removing parts 12 and 13, which are shown shaded, by means of an accurate machining operation, for example by polishing. As the directive surface for this operation, use is made of the surface 14' of the part 8. The height $h'$ of the part 8 is accurately adjustable. Owing to the fact that the surface 9 exceeds the surface 10 on either side in the direction of the gap height, this height $h'$ of the part 8 will invariably also be the height of the effective gap, irrespective of the position of the part 7 with respect to the part 8 (provided that the surface 10 lies within the surface 9).

Subsequently, surfaces 15*a* and 15*b* of the parts 7 and 8 are finished and finally a closing yoke, on which a coil is provided, is arranged along these surfaces.

Advantageously, initial use is made of two component parts each provided with two accurately finished surfaces along which the component parts engage one another. In FIG. 3, two such component parts are designated 16 and 17. Both parts are provided with two accurately finished surfaces 18, 19 and 20, 21 respectively. A glass foil 4 is interposed between surfaces 18 and 20. It has been found that, when the assembly is heated to a temperature lying in the softening range of the glass, not only surfaces 18 and 20 are secured to one another by the glass foil, but also surfaces 19 and 21 have grown together by recrystallisation and diffusion processes, so that the magnetic resistance of this joint becomes negligible. In order to increase the mechanical strength of this joint, a glass rod can be arranged in a groove 22 formed in either of parts 16 and 17 (in the figure, in part 17), which rod also softens on heating and provides a strong adherence at this point.

In the last-mentioned example, the glass 4, which is used as the non-magnetic material, is not restricted to the effective gap but also fills part of the space formed by the circuit parts 16 and 17. Such an additional amount of glass 23 imparts an additional rigidity to the circuit in the vicinity of the effective gap and also enables the height of this gap to be reduced by grinding to a desirable very small value without the risk of an appreciable reduction of the strength of the circuit in the proximity of the gap.

This additional amount of glass can be provided simply by arranging, prior to heating, a glass rod at the inner side of the ferromagnetic circuit parallel to, and in close proximity to, the effective gap (this rod is shown diagrammatically in FIGURE 3 by a broken circle). During heating, the glass spreads to form a layer as shown in the figure.

The surface 18 again exceeds the surface 20. It will be appreciated that such a relationship is not necessary for the surfaces 19 and 21 since there is no gap between them; surfaces 19 and 20 may be considerably larger than the surfaces 18 and 20. By using a flat piece of material as the component part containing the surfaces 18 and 19 (reference numeral 16 in the embodiment shown), the dimension *a* of which in the direction of the gap height exceeds the corresponding dimension *b* of a profiled component part (reference numeral 17), it is ensured that the surface 18 exceeds the surface 20; in addition only one of the component parts need be elaborately worked in order to provide the space 24 and the groove 22.

Finally, a guide face 27 is provided by removing parts 25 and 26, which are shown shaded, by grinding. As the



directive surface for this operation, use is made of a surface 27' of the part 17. If required, parts 28*a* and 28*b*, which are shown shaded, can also be removed by grinding. The coil of the magnetic recorder or reproducer head can be provided either on the part 16 or on the part 17.

With reference to FIG. 4 a method will now be described in which initial use is also made of two component parts 29 and 30, which are each provided with two accurately worked surfaces 31, 32 and 33, 34 respectively. However, a glass foil is interposed between each pair of surfaces, whilst, in the direction of the gap height, not only is surface 33 smaller than surface 31, but also surface 34 smaller than surface 32. Here also, the part 29 is a flat piece of material, the dimension of which, in the direction of the gap height, exceeds the corresponding dimension of the profiled part 30. After the heat treatment, parts 35, 36, 37 and 38, which are shown shaded, are removed by accurate machining, surfaces 39' and 40' of part 30 being used as the directive surfaces. The assembly is now provided with two guide faces 39 and 40.

Subsequently, the assembly is sawed in two along a plane 41, so that two circuit parts are produced which can each be completed by a closing yoke on which a coil is provided.

It should be noted that the assembly can also be cut up along one or more planes at right angles to the direction of the gap width, for example planes 42 and 43.

Thus, a number of circuit parts can be produced from a single part manufactured by the method in accordance with the invention. Obviously, a similar process can be used for the constructions shown in FIGURES 2 and 3.

What is claimed is:

1. A method of manufacturing magnetic heads for recording or reproducing magnetic recordings, comprising the steps of interposing a non-magnetic material capable of being softened when heated between machined exposed surfaces of two magnetic circuit parts, each of said surfaces having dimensions of height and width, each of said height dimensions being measured between top and bottom edges of the respective surface, the height dimension of the surface of one of said parts exceeding the height dimension of the other, heating the assembly to a temperature lying in the softening range of the non-magnetic material, the magnetic circuit parts having a higher softening range than the non-magnetic material, compressing said assembly during heating until a desired thickness between the surfaces is set, cooling the assembly, maintaining the top and bottom edges of said other surface between the top and bottom edges, respectively, of said one surface while the assembly is being heated and cooled, and machining one end of said assembly including both surfaces comprising the guide face of the head, the surface which is smaller in said height dimension determining the gap height of the head.

2. A method as claimed in claim 1, wherein the non-magnetic material comprises glass and the magnetic material comprises a sintered ferromagnetic oxide.

3. A method as claimed in claim 1 wherein each of said circuit parts is provided with a second surface, said second surfaces being in contact with each other before and after heating.

4. A method as claimed in claim 3, wherein at least one of said second surfaces has a groove formed therein which is filled, prior to heating, with said non-magnetic material.

5. A method as claimed in claim 1, wherein each of said component parts is provided with a second surface, said second surfaces being machined and having a glass foil interposed in a gap therebetween before the assembly is heated, said second surfaces also having dimensions of height and width, the height dimensions being measured between top and bottom edges of the respective surfaces, one of said second surfaces exceeding the other in the height dimension, the top and bottom edges of said

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other of said second surfaces being maintained between the top and bottom edges of said one surface while the assembly is being heated and cooled, and subsequent to cooling, dividing the assembly in two parts, each of said parts having a pair of surfaces between which a non-magnetic material is interposed.


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Jan. 14, 1964

S. DUINKER ETAL

3,117,367

METHOD OF MANUFACTURING A MAGNETIC HEAD HAVING A GLASS SPACER

Filed June 15, 1959

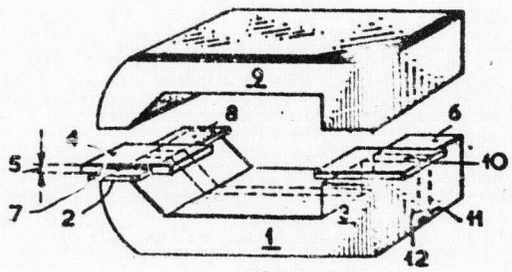


FIG. 1

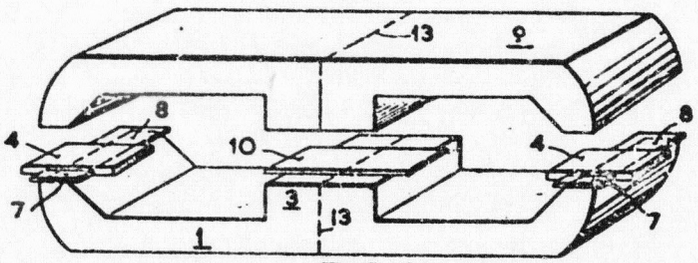


FIG. 2

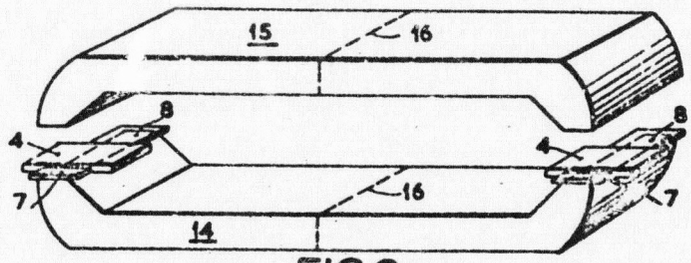


FIG. 3

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United States Patent Office

3,117,367
Patented Jan. 14, 1964

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# 3,117,367
# METHOD OF MANUFACTURING A MAGNETIC HEAD HAVING A GLASS SPACER

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Filed June 15, 1959, Ser. No. 820,424
Claims priority, application Netherlands July 3, 1958
5 Claims. (Cl. 29—155.5)

The invention relates to a method of manufacturing recording and/or reproducing heads; usually, these heads comprise at least two circuit portions of sintered, oxidic, ferromagnetic material, spaced apart by a useful gap filled with glass. The glass serves as non-magnetic material to protect the useful gap and also acts to connect the two circuit portions mechanically with each other. The process of manufacture starts with two portions each provided with at least one precisely machined surface, these portions being joined with the machined surfaces facing each other with an intermediate glass sheet, the thickness of the sheet being a few percent larger than the finally desired gap length. This assembly is then heated to the softening range of the glass, the portions being then pressed toward each other at a temperature lying in the said softening range and with such a pressure that, subsequent to the hardening of the glass, the correct gap length is reached. The gap height is determined, subsequent to cooling of the assembly, by accurately shaping (for example polishing) the guide surface formed by the two circuit portions on the top side of the head.

The invention furthermore relates to magnetic recording and/or reproducing heads manufactured by this method.

This known method is particularly intended for the manufacture of heads of high resolving power, in which the gap has a length of only a few microns. In this case the thickness of the glass sheet between the accurately machined surfaces is so small that, during the heating at a temperature in the softening range of the glass and the simultaneous compression, the viscosity forces in the softened glass are capable of keeping this glass in place between the said surfaces and of preventing the glass from being pressed away out of the gap between the said surfaces by the high pressure exerted.

It appears, however, that this is not the case with heads in which the gap length is of the order of 10 microns or more.

It will be obvious that under the conditions set forth the adjustment of the gap length to the correct value is not possible when the glass flows away.

Efforts have been made to prevent the glass from flowing away by providing, at the ends of the gap, metallic foils or wires, the thickness of which corresponds to the desired gap length and the melting point of which exceeds the temperature of the heated circuit portions and the intermediate glass. It is found, however, that at the said temperature (about 900° C.) these metal foils or wires react either with the glass or with the ferrite or with both; this, of course, affects adversely the magnetic and mechanical properties of the heads and renders useless the adjustment of the gap length to the correct value.

If the material of these foils or wires would not be

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substantially deformed during the said reactions, a head could be manufactured, which fulfills the purity requirements of the material; this could be done by starting from circuit portions of sufficient width and by removing material in the surroundings of the gap ends, but since the said reactions have their effect to a comparatively large depth in the gap and in the surrounding material, this method would give rise to considerable loss of material.

In addition, apart from the requirement that the material of the foils or wires should not melt at the said temperatures and that this material should not react with the glass, the ferrite or with both, this material must be readily adjustable to the required thickness (10 microns or more); it must also maintain its mechanical rigidity at the said temperatures, in order that it does not break down under the high pressures required in the pressing process. Most metallic materials do not fulfill the latter requirement, so that also for this reason the last-mentioned method gives rise to difficulties in adjusting the gap length to the correct value.

The invention has for its object to mitigate these disadvantages; the method according to the invention is characterized in that, prior to heating, mica spacers are provided in addition between the said surfaces of the portions, the thickness of these spacers being substantially equal to the finally desired gap length.

The invention will now be described more fully with reference to the figures of the drawing.

Referring to FIG. 1, reference numeral 1 designates a circuit portion of sintered oxidic, ferromagnetic material, the surface 2 of which operates as a gap surface and the part 3 of which forms part of the closing yoke of the completed product. On the surface 2 is arranged a glass sheet 4, of which the dimension 5 exceeds by some percent, if necessary even a few tens of percent the finally desired gap length, which is of the order of 10 microns or more. On the surface 6 of the part 3 is also arranged a glass sheet 10, which, however, may be materially thinner than the sheet 4.

It should be noted that it is advisable to use glass which has an expansion coefficient, at the temperature at which the magnet head is used, which is substantially equal to the expansion coefficient of the ferromagnetic material and differs, for example, not more than 5% therefrom; preferably, however, glass is used having an expansion coefficient in the whole temperature range between the temperature at which the magnet head is used and the temperature at which the glass softens, which is substantially equal to the expansion coefficient of the ferromagnetic material and differs, for example, not more than 10% therefrom.

Reference numerals 7 and 8 designate the mica spacers, of which the thickness is, as far as possible, equal to the desired gap length.

On the assembly thus formed is arranged a second circuit portion 9, which may be identical to the first circuit portion; it may, however, also be a non-profiled piece of sintered, oxidic, ferromagnetic material. This second circuit portion is shown in the figure in a position, in which it is not yet arranged on the first circuit portion provided with glass and mica.

The assembly thus obtained is heated at a temperature in the softening range of the employed glass and the two circuit portions are compressed. Owing to the mica

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spacers no glass can be pressed out of the gap during the pressing process, after the desired gap length has been definitely attained.

It should be noted that, when the desired gap length is attained, the distance between the surface 6 of the closing piece 3 and the corresponding surface of the second circuit portion must be sufficient to hold the compressed glass sheet 10, which serves only as a mechanical connection between the two circuit portions 1 and 9 and which, as such, may be replaced by other means.

After cooling, those parts of the gap which are filled with mica can be ground away or sawed off and the guide surface of the head can be machined at the same time.

If desired, the structure may be sawed along one or more planes at right angles to the direction of the gap width, for example, along the planes 11 and 12.

Thus a plurality of circuits can be obtained from one structure manufactured in accordance with the invention.

It will be obvious that the circuit portions may be arranged in a twin structure, as shown in FIG. 2. After carrying out the same process as described above, the assembly must be sawed along a plane 13, so that two structures as described with reference to FIG. 1 become available.

Similarly the process may start from two portions 14 and 15, shown in FIG. 3. After carrying out the process described with reference to FIG. 1, the assembly must be sawed along a plane 16, so that two circuit portions are available, each of which may be completed with a closing yoke.

Also the structures shown in FIGS. 2 and 3 may be sawed along one or more planes at right angles to the direction of the gap width as described with reference to planes 11 and 12 of FIG. 1.

While the invention has been described with reference to specific embodiments, various other modifications thereof will be readily apparent to those skilled in the art without departing from the inventive concept, the scope of which is set forth in the appended claims.

What is claimed is:

1. A method of manufacturing magnetic heads consisting of at least two circuit parts of sintered oxidic ferromagnetic material with a gap therebetween filled with glass serving as a protection and a mechanical connection means, comprising: accurately machining at least one surface of each of said two circuit parts, arranging said parts one upon the other with the machined surfaces facing each other, placing a glass sheet having side portions and top and bottom portions between the parts with the top and bottom portions contacting said surfaces, the thickness of the glass sheet being greater than the finally desired gap length, placing mica spacers between said surfaces adjacent to and abutting only the side portions of said glass sheet, said mica having a higher melting temperature than said glass, said mica spacers having a thickness substantially equal to the finally desired gap length, heating the assembly thus obtained to a temperature in the melting range of the glass, pressing the parts against each other at said temperature, cooling the assembly, and grinding away the portions of the circuit parts including the mica when the assembly has been cooled.

2. A method of manufacturing magnetic heads consisting of at least two circuit parts of sintered oxidic ferromagnetic material with a gap therebetween filled with glass serving as a protection and a mechanical connection means, comprising: accurately machining two surfaces of each of said two circuit parts, arranging said parts one upon the other with corresponding machined surfaces of opposing parts facing each other, placing a glass sheet between each pair of facing machined surfaces, the thickness of the glass sheets being greater than the finally desired gap length, each glass sheet having side portions and top and bottom portions with the top and bottom portions contacting the facing surfaces, placing mica spacers between one pair of said surfaces adjacent to and abutting only the side portions of the glass sheet therebetween, said mica having a higher melting temperature than said glass, said mica spacers having a thickness substantially equal to the finally desired gap length, heating the assembly thus obtained to a temperature in the melting range of the glass, pressing the parts against each other at said temperature, cooling the assembly, and grinding away the portions of the circuit parts including the mica when the assembly has been cooled.



3. A method of manufacturing magnetic heads consisting of at least two circuit parts of sintered oxidic ferromagnetic material with a gap therebetween filled with glass serving as a protection and a mechanical connection means, comprising: accurately machining three surfaces of each of said two circuit parts, arranging said parts one upon the other with corresponding machined surfaces of opposing parts facing each other, placing a glass sheet between each pair of facing machined surfaces, the thickness of the glass sheets being greater than the finally desired gap length, each glass sheet having side portions and top and bottom portions with the top and bottom portions contacting the facing surfaces, placing mica spacers between the two outer pairs of surfaces adjacent to and abutting only the side portions of the glass foil therebetween, said mica having a higher melting temperature than said glass, the thickness of said spacers being substantially equal to the finally desired gap length, heating the assembly thus obtained to a temperature in the melting range of the glass, pressing the parts against each other at said temperature, cooling the assembly, grinding away the portions of the circuit parts including the mica when the assembly has been cooled, and separating the assembly into two portions, each portion comprising a set of surfaces with an intermediate glass sheet and spacers and a set of surfaces with an intermediate glass sheet.

4. A method of manufacturing magnetic heads consisting of at least two circuit parts of sintered oxidic ferromagnetic material with a gap therebetween filled with glass serving as a protection and a mechanical connection means, comprising: accurately machining two surfaces of each of said two circuit parts, arranging said parts one upon the other with corresponding machined surfaces of opposing parts facing each other, placing a glass sheet between each pair of facing machined surfaces, the thickness of the glass sheets being greater than the finally desired gap length, each glass sheet having side portions and top and bottom portions with the top and bottom portions contacting the facing surfaces, placing mica spacers between opposing sets of surfaces adjacent to and abutting only the side portions of said glass foil, said mica having a higher melting temperature than said glass, the thickness of said spacers being substantially equal to the finally desired gap length, heating the assembly thus obtained to a temperature in the melting range of the glass, pressing the parts against each other at said temperature, cooling the assembly, separating the assembly into two portions each of which comprises a set of two surfaces, and grinding away the portions of the circuit parts including the mica.

5. A method of manufacturing magnetic heads consisting of at least two circuit parts of sintered oxidic ferromagnetic material with a gap therebetween filled with glass serving as a protection and a mechanical connection means, comprising: accurately machining at least one surface of each of said two circuit parts, arranging said parts one upon the other with the machined surfaces facing each other, placing a glass sheet having side portions and top and bottom portions between the parts with the top and bottom portions contacting said surfaces, the thickness of the glass sheet being greater than the finally desired gap length, placing mica spacers between said surfaces adjacent to and abutting only the side portions of said glass sheet, said spacers having a thickness sub-

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stantially equal to the finally desired gap length, heating the assembly thus obtained to a temperature in the melting range of the glass, pressing the parts against each other at said temperature, cooling the assembly, and grinding away the portions of the circuit parts including the mica when the assembly has been cooled.


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Nov. 8, 1966 R. F. PFOST 3,283,396

MAGNETIC TRANSDUCER ASSEMBLY AND MANUFACTURE

Original Filed April 17, 1961 3 Sheets-Sheet 1

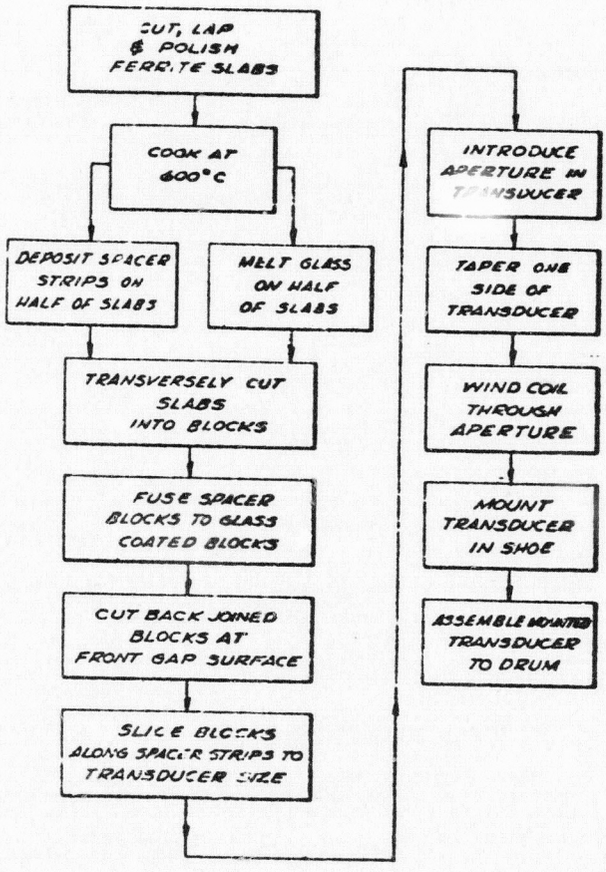


FIG. 1

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MAGNETIC TRANSDUCER ASSEMBLY AND MANUFACTURE

Original Filed April 17, 1961 3 Sheets-Sheet 2

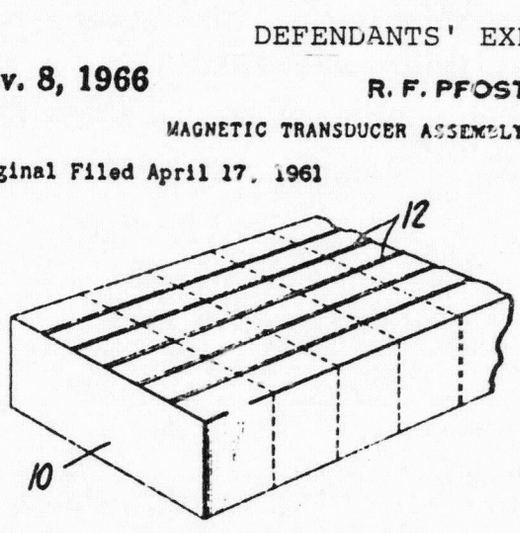


FIG_2

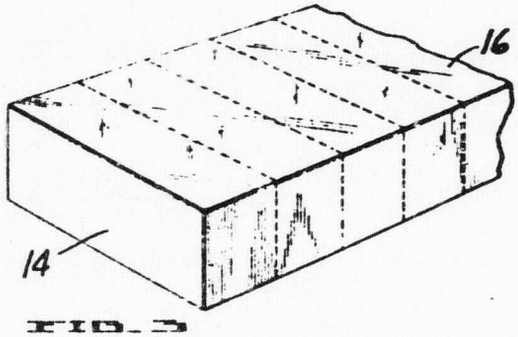


FIG_3

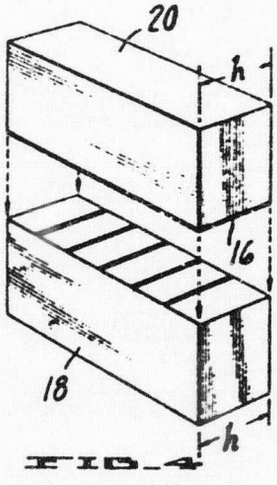


FIG_4

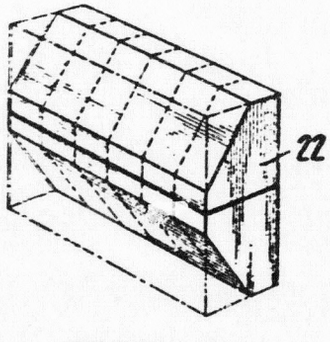


FIG_5

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Nov. 8, 1966 R. F. PFOST 3,283,396

MAGNETIC TRANSDUCER ASSEMBLY AND MANUFACTURE

Original Filed April 17, 1961 3 Sheets-Sheet 3

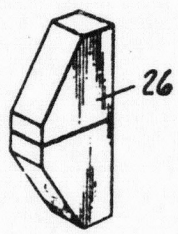


FIG_6

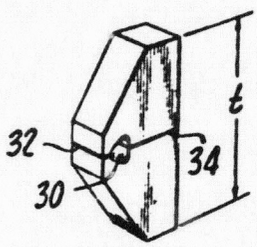


FIG_7

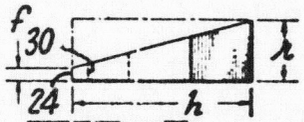


FIG_8

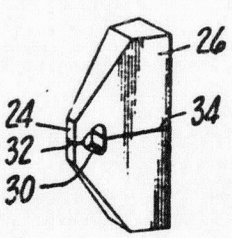


FIG_9

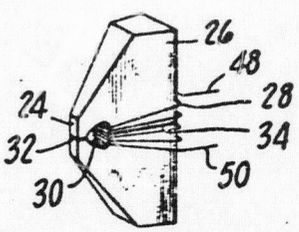


FIG_10

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DEFENDANTS' EXHIBIT L

United States Patent Office

3,283,396

Patented Nov. 8, 1966

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3,283,396

# MAGNETIC TRANSDUCER ASSEMBLY AND MANUFACTURE

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Original application Apr. 17, 1961, Ser. No. 103,424. Divided and this application May 12, 1964, Ser. No. 377,445

3 Claims. (Cl. 29—155.5)

This is a division of application Serial No. 103,424 filed April 17, 1961.

This invention relates to a method and means for manufacturing magnetic transducers, and in particular to a method and means for making and employing magnetic heads formed substantially from a ferrite material.

Ferrites are highly preferable for use as cores of magnetic transducers or heads because they are relatively hard, afford lower losses during the recording and reproducing modes, and operate well at high frequencies. When techniques normally utilized for construction of magnetic tape transducers from metallic magnetic materials and specifically, the techniques of forming the nonmagnetic gap are employed in the construction of a magnetic tape transducer intended for contact recording, such a transducer assembly being formed from ferrite, the well-defined, sharp corners of the ferrite material at the junction formed by the nonmagnetic gap and the ferrite have a tendency to chip and crack and, in general, erode away until satisfactory operation of the transducer is no longer possible due to poor resolving power.

In the prior art, heads utilizing ferrite cores have been made with metallic pole places, such as Alfenol, disposed on either side of the nonmagnetic gap to provide a mechanically strong structure. However, such a head structure is subject to rapid wear requiring frequent replacement when operating in contact with magnetic tapes, especially at high relative speeds. Furthermore, changes in structure of the head due to abrasion and wear vary the resolution and sensitivity characteristics of the head. In addition, the manufacture of such heads is tedious, time-consuming and uneconomical because they must be manufactured individually to provide proper gap dimensions.

It has been proposed to employ a glass bond or embedment to form the nonmagnetic gap of a ferrite core transducer to provide improved head wear resistance, to minimize gap erosion, and to provide improved gap definition, better resolution and greater sensitivity. But the manufacture of glass gap heads for use in video, television or high frequency magnetic tape apparatus necessitates special techniques. For example, in a television tape recorder that utilizes a plurality of expensive magnetic heads having relatively narrow gaps disposed circumferentially on a rotary drum, the heads need be perfectly aligned and properly adjusted to avoid phasing errors and improper head-to-tape contact. Therefore, it would be desirable to provide a method for manufacturing ferrite core magnetic heads by mass production methods wherein all the heads have substantially the same precise configuration, and still derive the advantages and features of a ferrite core head having a gap formed by means of a glass bond.

An object of this invention is to provide a novel and improved method for manufacturing a magnetic transducer utilizing a ferrite material as the core.

Another object of this invention is to provide an improved method for forming a ferrite core transducer having a relatively narrow nonmagnetic gap with a nonmagnetic rigid material disposed in the gap to provide structural strength.

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Another object is to provide a method for manufacturing precisely formed ferrite core heads having accurate gap dimensions on a mass production basis in an economical manner.

Another object of this invention is to provide a method for forming a magnetic transducer having a ferrite core and a glass gap, such glass forming a chemical bond so as to establish a substantially continuous molecular structure but a discontinuous magnetic structure.

According to this invention, a plurality of lapped and polished ferrite slabs of high density and low porosity have a series of spacer layers or strips deposited on one surface, the thickness of such layers determining the gap length of a finished transducer. A like plurality of similar ferrite slabs are coated with a thin layer of glass on a corresponding surface, such glass having a coefficient of thermal expansion essentially the same as that of the ferrite material. All the slabs are sliced transversely to the parallel spacer strips into ferrite blocks. Each ferrite block having spacer strips is fused to a block having a glass layer, by heating the glass to melting while the blocks are clamped under high pressure in a neutral atmosphere. After cooling, the joined blocks are severed along the spacer strips to provide transducer size units having a nonmagnetic glass gap ready for further shaping and assembly. The shaped and finished transducer assemblies are all substantially uniform in dimension and physical characteristics, and a multiplicity of such mechanically stable transducers may be mounted in equally spaced relation about the periphery of a rotary drum assembly of a magnetic tape apparatus to provide recording and reproducing operation that has high resolution and improved sensitivity.

In an embodiment of this invention, a ferrite material having relatively high density and low porosity is cut and lapped into rectangular type slabs, which are polished and then heated to eliminate any contaminants. A plurality of parallel layers of spacer material having a high melting point are deposited longitudinally on one surface of half of the slabs, and a thin layer of glass having a relatively low melting temperature is deposited coextensively on a corresponding surface of the other half of the slabs. The slabs having the spacer material are then cut transversely relative to the length of the spacer strips, and the slabs having the glass are cut along the same transverse dimension thereby providing ferrite blocks with one dimension that is close to the overall height of the finished transducer.

Each ferrite block having the spacer strips is fused to a ferrite block having a layer of glass under very high pressure, thus causing the two blocks to settle together against the spacer material, thereby forcing the melted glass that is present in excess to flow out from between the blocks. The blocks are thus joined at the surfaces carrying the spacer and glass material respectively, thereby forming a magnetic body having a nonmagnetic layer disposed in a substantially central plane therein that will serve as the nonmagnetic gaps of several magnetic transducers or heads. The joined block assembly has portions cut back to provide a smaller surface for contacting a magnetic tape that will cooperate with such surface during the recording or reproducing modes. The block assemblies are then partitioned into transducer size units by cutting along the lines of the spacer strips thereby entirely eliminating the spacer material. Thus, a plurality of unitary or integral transducer units in the form of fused ferrite block portions, each having a nonmagnetic gap material of glass centrally secured therein that forms a molecular bond with the ferrite, are provided ready for further machining to a desired shape.

To accommodate an energizing coil such as is conventionally used with magnetic transducers, an aperture

is formed in the transducer unit along the plane of the rigid gap material through a portion thereof close to the effective gap face at a predetermined location. The effective gap face or front gap surface is defined as that surface which the magnetic tape traverses during operation of the magnetic tape apparatus. In contrast to the rear gap surface that is not employed directly in the transducing process. Thus, a high reluctance magnetic path is provided by disposition of the aperture adjacent to the effective gap.

The transducer is then tapered to a wedge-like shape converging from the rear gap surface to the front gap surface so that the width of the effective gap, i.e., the dimension of the surface of the front gap perpendicular to the longitudinal movement of the tape, corresponds closely to the width of the tape track to provide enhanced sensitivity by virtue of the large rear gap area as compared to the front gap area, thereby providing a considerably lower rear gap reluctance than would exist if the entire transducer were constant in thickness. However, since the width of the rear gap surface is maintained substantially larger, additional structural strength is provided for the transducer assembly. After tapering of the transducer unit, the energizing coil is coupled to the transducer.

The finished transducer assembly having the wedge shape is then joined by means of an assembly jig to a nonmagnetic mounting shoe having a cooperating wedge-like cutout. The shoe is precisely positioned on a rotary drum assembly of a magnetic tape apparatus in a similar relation as when positioned on the jig so that the transducer becomes fixed on the drum whereby only a predetermined gap portion projects from the drum periphery for contact with a magnetic medium or tape. When a plurality of shoe mounted transducers are assembled to the rotary drum, the precision mounting of transducer to shoe and shoe to drum assures that all the transducer front gap faces protrude substantially the same amount from the periphery of the drum along a radial direction. Furthermore, simple means are provided to adjust the quadrature or phasing relation of the transducers, and once such adjustment is made, such relation remains fixed during operation for practical purposes.

The invention will be described in greater detail with reference to the drawing in which:

FIGURE 1 is a flow chart setting forth various steps of the inventive method;

FIGURE 2 is a perspective view of a cut and polished ferrite slab having space; layers deposited thereon, in accordance with the invention;

FIGURE 3 is a perspective view of a cut and polished ferrite slab having a glass layer deposited thereon;

FIGURE 4 is a perspective view of two ferrite blocks cut from the slabs of FIGURES 2 and 3 respectively, and processed ready for joining;

FIGURE 5 shows a joined ferrite block assembly that has been cut back, according to the invention;

FIGURE 6 represents a transducer size ferrite unit partitioned from the assembly of FIGURE 5;

FIGURE 7 illustrates a transducer unit with an aperture formed therein;

FIGURE 8 is an enlarged end view of the same transducer unit after tapering, in accordance with one aspect of the invention;

FIGURE 9 depicts the shaped transducer unit of FIGURE 8 in a front perspective view; and

FIGURE 10 shows a shaped transducer with an energizing coil coupled thereto fabricated in accordance with the method of the invention.

To aid in the explanation of the invention, the following letters will be used hereinafter as follows:

*t*—the overall length of the transducer unit in the direction of tape travel

*f*—the width of the front gap surface that is perpendicular to the direction of the moving tape, and that approximates the width of a tape track that will cooperate with the transducer during record of reproduce operation

*r*—the width of the rear gap surface that is parallel to the dimension *f*

*h*—the height of the transducer unit measure from the effective gap face or front gap surface to the rear gap surface, and orthogonally to both surfaces



Similar numerals and designations refer to similar elements throughout the drawing.

In accordance with an embodiment of the invention, a ferrite body that may be formed from a ferrite material is cut, parallel lapped into several rectangular slabs, and one longitudinal surface of each slab is polished to a specular finish under a high pressure of about 60–100 lbs. per square inch on an optically smooth surface. As indicated in the flow chart of FIGURE 1, the ferrite slabs are heated or "cooked" at about 600° centigrade to remove undesirable contaminants. Thereafter, one half of the slabs 10 have a series of evenly spaced parallel linear layers of spacer material 12 deposited thereon, as shown in FIGURE 2. The thickness of the slab 10 may be about one half of the desired overall length, *t*, of the finished transducer, *t* being about .250 inch. The spacer material 12 may be silicon monoxide or aluminum oxide, for example, that has been deposited by evaporation, spraying, or other known methods for depositing a precise thickness of material. Each spacer strip 12 may be approximately .008 inch wide and approximately 80 micro-inches deep, by way of example, such layer thickness being instrumental in determining the ultimate effective gap length. The spacing between each of the strips may be .046 inch, for example, such dimension serving to determine the approximate extent of *r*, the rear gap surface, and also to limit the width, *f*, of the effective front gap surface.

On the other half of the slabs 14, a thin glass layer 16 is deposited, as shown in FIGURE 3, coextensively on a surface corresponding to the surface of the slab 10 on which the spacer material 12 is deposited. The glass 16, which has a low melting temperature relative to the spacer material 12 and a coefficient of thermal expansion substantially the same as that of the firrite, preferably is noncorrosive, and is of such composition that the magnetic properties of the ferrite are not affected by fusion of the ferrite and glass. The glass layer 16 may be melted onto the ferrite slab 14 at about 550–900° centigrade, which temperature is sufficient to soften the glass and to cause the glass to wet the ferrite.

With the slab 10 properly dimensioned, and each surface in orthogonal relationship to the adjacent surfaces, the ferrite slab 10 with the spacer material is cut transversely to the spacer strips 12 to provide blocks 18 such as shown in FIGURE 4, such blocks 18 having a dimension approximately the overall height *h* of the finished transducer. At the same time, the ferrite slab 14 is cut along the same dimension as the slab 10 to provide glass coated blocks 20, such as shown in FIGURE 4, for joining with the blocks 18.

The ferrite blocks 18 and 20 are joined by setting the glass coated block 20 onto the block 18 with the surface having the spacer lines 12 facing the corresponding surface having the glass layer 16. With the blocks 18 and 20 securely fixed relative to each other, high pressure of about 3000 lbs. per square inch may be applied when the glasss commences to soften, urging the blocks closer together until both surfaces are resting against the spacer strips. The block assembly 22 is heated in a neutral atmosphere, such as in an environment of an inert gas as argon, at a temperature between 550–900° centigrade which is sufficient to allow the excess melted glass to flow from between the blocks. The glass 16, having a relatively low melting point, flows and fills in the areas between the layers of spacer material 12, and the excess glass is forced out from between the contiguous surfaces during the fusing process. The assembly 22 is cooled to an ambient rom temperature thereby causing the blocks

DEFENDANTS' EXHIBIT L





18 and 20 to be integrally joined by means of the glass bond 16 that has a thickness of approximately 80 microinches, such as determined by the thickness of the spacer material 12.

The joined assembly 22 is lapped and polished, and the gap width is checked and inspected under a microscope. At this point, the assembly 22 is ground down by cutting back at about a 30° angle at each end of the front gap surface until the total area of the front gap surface is reduced in length *t* from .25 inch to about .080 inch, as indicated in FIGURE 5. The reduced front gap surface allows satisfactory unit pressure at the gap area to be obtained with a low total force between the transducer and the tape. This low total force subjects the recording medium to decreased mutilation and lessens the frictional effects thus preventing oxide deposits from building up on the transducer and providing increased tape life.

Thereafter, the joined assembly 22 is partitioned by cutting along the spacer lines 12, with a diamond saw that has a width of about .013 inch, for example, which is slightly larger than the .008 inch width of the spacer layers, thus eliminating the spacer material 12 from the ferrite assembly 22. Also, as the .008 inch wide layers are spaced at about .040 inch, the cutting operation provides gap faces, rear and front respectively, that are each about .035 inch wide. The severed units or blanks are now in a desired transducer size 26, as shown in FIGURE 6, and need only be shaped to a desired configuration and wired to serve as a magnetic recording or reproducing head.

To allow for electrical coupling of an energizing coil 28 to the transducer unit 26, an aperture 30 of about .025 inch in diameter is drilled along the plane of the glass bond 16 through the transducer unit 26, but asymmetrically relative to the front gap 32 and rear gap 34 (FIGURE 7). The aperture 30, which may be formed by ultrasonic means for example, is located preferably close to the effective front gap 30, about 0.28 inch from the aperture center to the front gap surface 24, to provide a high reluctance magnetic path adjacent thereto. The aperture 30 is preferably pear shaped to provide increased mechanical strength and reduced reluctance in the area adjacent to the front gap.

In accordance with another feature of the invention, the transducer unit 26 is shaped into a wedge-like form by tapering one side from the rear gap 34 to the front gap 32 at about an angle of 14°, as illustrated by FIGURES 8 and 9. Improved sensitivity is afforded because of the ratio of the reluctance of the front gap 32 relative to that of the rear gap 34 is increased, and at the same time a strong mechanical structure is provided. The wedge type transducer 26 conforms with a rotary drum mounting shoe 36 that has an accommodating retaining cutout portion 38, such as shown in U.S. patent application 103,424. Finally, as shown in FIGURE 10, a coil 28 of insulated copper wire for transducing the processed signal, is wound through the aperture 30 and around the rear gap portion and surface of the transducer 26.

While the above description has shown, described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the method illustrated may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. The method of forming magnetic transducer assemblies comprising the steps of: depositing spacer strips of material having a relatively high melting point longitudinally on a surface of a lapped and polished ferrite slab having a predetermined configuration; depositing a thin layer of glass on a corresponding surface of another polished ferrite slab, said slabs having substantially the same configuration and physical characteristics; cutting the slabs in a direction transverse to the longitudinal strips of spacer material to form blocks having desired dimensions; joining each of the blocks containing spacer material with each of the glass coated blocks in an atmosphere having a temperature of about 550–900° centigrade under high pressure to form a nonmagnetic gap layer between said formed blocks; cutting the joined assembly along the longitudinal strips of spacer material perpendicular to the joined surfaces to remove said spacer material and provide transducer size units and define sides of said units; forming an aperture along a portion of the gap layer in each of said transducer units to define front and rear gaps; and winding an electrical coil through said aperture.



2. The method of claim 1 further comprising: shaping at least one of said sides of each unit to form a planar surface extending through said front and rear gaps and inclined to the other side surface.

3. The method of forming a plurality of magnetic transducer assemblies comprising the steps of: cutting a ferrite body having high density and low porosity into a rectangular form; parallel cutting said rectangular form to provide an even number of slabs having surfaces that are disposed substantially orthogonally to each other; polishing a surface of each of said slabs to a specular finish; heating said slabs at a temperature of about 600° centigrade to eliminate contaminants therefrom; depositing parallel strips of silicon monoxide on said polished surface of each of one half of said slabs for providing spacer strips; depositing a thin glass layer coextensive with a corresponding polished surface on each of the other half of said slabs; cutting said one half of said slabs transversely to the spacer strips to provide ferrite blocks having a predetermined configuration; cutting said other half of said slabs to substantially the same configuration as that of said half of said slabs to form similar blocks; joining each block having spacer strips thereon to a block having a glass layer at a temperature between 550–900° centigrade with a pressure of about 3,000 pounds per square inch applied to urge said blocks closely together; cutting back a front gap surface of said joined block assemblies at about 30° to provide a substantially lesser area for magnetic tape contact; cutting along and removing the spacer strips of said joined assemblies to define sides and to provide transducer size units; forming an aperture in each of said transducer units through a portion of said glass gap layer and closely adjacent to said front gap surface; tapering one side of said transducer size unit from the rear gap surface to the front gap surface; and winding an electrical coil through said aperture and around said transducer unit.


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JOHN F. CAMPBELL, *Primary Examiner.*

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DEFENDANTS' EXHIBIT M.

Feb. 14, 1967 M. V. DE JEAN ET AL 3,304,358

METHOD OF ASSEMBLING AND BONDING TOGETHER LAMINATIONS TO FORM LAMINATED CORES FOR ELECTRICAL INDUCTIVE DEVICES

Original Filed Jan. 5, 1959

Fig. 1

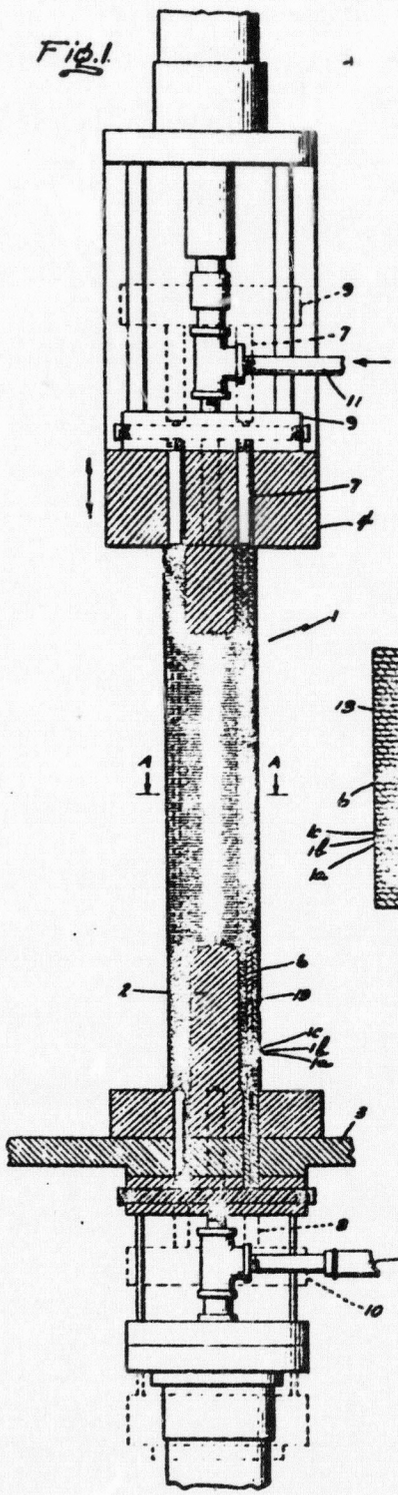


Fig. 2

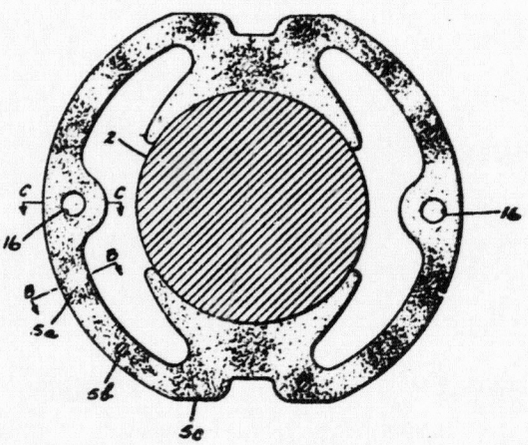


Fig. 3

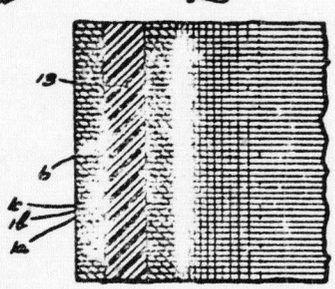


Fig. 4

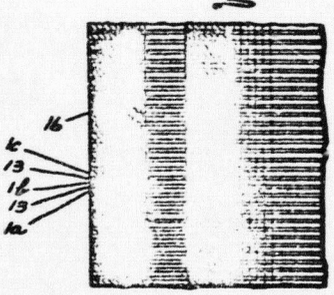


Fig. 5

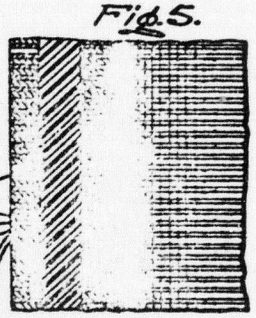
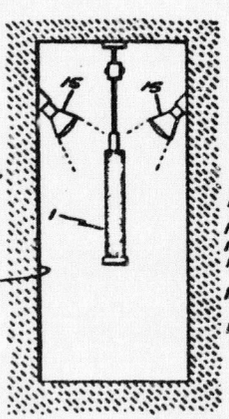


Fig. 6



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DEFENDANTS' EXHIBIT M

United States Patent Office

3,304,358

Patented Feb. 14, 1967

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3,304,358

# METHOD OF ASSEMBLING AND BONDING TOGETHER LAMINATIONS TO FORM LAMINATED CORES FOR ELECTRICAL INDUCTIVE DEVICES

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Continuation of application Ser. No. 785,061, Jan. 5, 1959. This application Oct. 28, 1963, Ser. No. 320,255

3 Claims. (Cl. 264—159)

This invention relates to a method of constructing cores, and more particularly to a method of assembling and bonding together laminations to form laminated cores of electric inductive devices, such as, dynamoelectric machines. This application is a continuation of our copending application Serial Number 785,061, filed January 5, 1959, and now abandoned.

Dynamoelectric machines, i.e., motors and generators, conventionally includes a stator core member and a rotor core member concentrically disposed within the stator member, at least one and frequently both of the members having a plurality of windings thereon. These core members are conventionally formed of a piurality of relatively thin laminations punched from magnetic steel. The number of laminations comprising the core conventionally have been selected by weight or by mechanical metering devices. Such a stack of laminations is then assembled and held together by welding, riveting, keying, or bonding the core with bonding material between the laminations. It is, of course, desirable to bond such laminated core structures together into a solid unitary piece without the use of welds, rivets, keys, or the coating of the laminations with bonding material between the laminations.

It is further desirable to eliminate the complex keying and riveting machines necessary to perform the respective functions and to eliminate the lamination stack sizing or selecting machines heretofore employed and to provide a simple means for readily sizing or selecting the laminated stacks in production.

It is an object of this invention to provide an improved method of assembling and bonding laminations together to form laminated cores for electrical inductive devices.

Another object of this invention is to provide an improved method of producing laminated cores which permits the formation of cores with the desired stack length from a relatively long stack of laminations already secured together.

Another object of the invention is to provide an improved method for assembling together laminated cores.

According to one form of the invention, which now forms the subject of our copending division application, a stack of core laminations, having winding accommodating means and aligned holes spaced from such means, are securely held together by a cured adhesive or resinous material such as a thixotropic heat curable, thermosetting epoxy resin, in a passageway extending through the stack of laminations. Some of the resin may be drawn by capillary action or forced under pressure between the laminations in the area of the holes. Under such conditions, the resin remaining in the hole may or may not be removed so that a "plastic" rivet may or may not remain in the hole. During curing of the resin, there is a secondary flow characteristic of the resin which results in the resin having a low viscosity, and thus the resin penetrates more freely into the laminations. Upon curing of the resin, the core is firmly bound together by (1) a plastic (or cured resinous) rivet extending through a hole or opening in the core, or (2) plastic material disposed between the laminations in the area of and surrounding the holes, or (3) a combination of these.

The above described core may be readily produced by

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the improved method of the present invention. In accordance with one form of the method, curable resin, such as, the aforementioned heat curable epoxy resin, is first introduced, under pressure if desired, through the holes or passageways in the stack of core laminations held together. The resinous material may be drawn (as by capillary action), or forced under pressure, between the laminations in the area of the passageway. If the resin is permitted to deposit in one of the aforesaid manners, between the laminations, the resinous material remaining in the passageways may, if desired, but need not necessarily, be removed from the passageways. The resin is cured, as, for example, by heating the stack (in the case of heat curable resin) to cure the resin. The stack may be assembled, if desired, but not necessarily, in a relatively long length and the individual stack heights may be selected by dividing the stacks at the desired points as, for example, by slicing.

The invention together with additional objects and advantages thereof will be best understood from the following description of a specific embodiment, when read in connection with the accompanying drawing, in which:

FIG. 1 is an elevation view, partly in section, illustrating one method of introducing resinous material into openings in the core laminations;

FIG. 2 is a cross section through the stack of core laminations taken along plane A—A of FIG. 1 and illustrating in plan view a typical core lamination;

FIG. 3 illustrates a partial elevation view, in section, of a portion of a stack of core laminations taken along plane B—B of FIG. 2 and illustrating a plastic rivet in an opening to the core laminations;

FIG. 4 is a partial elevation view, in section, taken along plane C—C of FIG. 2, illustrating an embodiment of the instant invention wherein the laminations are bound together by plastic material between the laminations;

FIG. 5 is a partial elevation view, in section, of a passageway in a stack of core laminations wherein the laminations are secured together by both a plastic rivet and plastic material having been deposited between the laminations; and

FIG. 6 illustrates schematically a method of baking the core structure to set the resin.

Referring to FIG. 1, there is illustrated the introduction of the resinous material into passageways formed of holes in a stack of laminations. The core laminations 1*a*, 1*b*, 1*c*, etc., are stacked on a mandrel 2 for orientation, thereby forming the lamination stack shown generally as 1. The stack may be of the desired height; or, in the alternative, it may be of a height many times that needed to form the desired single core member and the proper stack height may later be selected as hereinafter explained. The stacked laminations are then placed in a holding device, for example, between the stationary frame 3 and movable frame 4 which are brought together to securely hold the laminations 1 and mandrel 2. As more clearly seen in FIG. 2, the core laminations contain a plurality of holes 5*a*, 5*b*, 5*c*, etc., which are so aligned on the mandrel that passageways 6 are provided through the finished core. Suitable openings through conduit 7, 8 are aligned with passageways 6 of the core laminations by the movement of members 9 and 10 from the position shown in phantom in FIG. 1 to the position shown in solid lines in FIG. 1. Resin, such as the aforementioned epoxy resin, may then be introduced through inlet conduit 11 which connects with an opening in the manifold 9, which opening is, in turn, in communication with the openings in conduits 7. Similarly, the air can be removed from the passageways 6 through the openings in conduits 8, manifold 10, and exhaust conduit 12. There is a natural tendency for the resin to be drawn between the laminations due to capillary action; the stack of laminations forming a sort of wick

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for the resin. The material 13 may, however, if desired, be injected into the passageways 6 with sufficient pressure to assist or force the material to deposit or penetrate between the laminations.

The stack of laminations is then heated or baked to cure the resin, as, for example, in the oven 14, FIG. 6, by the heat lamps 15. In the event that the resinous material is the above mentioned epoxy resin, the stack may be baked, for example, for about 15 minutes at a temperature of about 150° C. This is left in the passageways 6, as best seen in FIG. 3, a plastic rivet 13 which retains the core laminations. In addition to the plastic rivet 13 as indicated in FIG. 3, if the resin is injected into the passageways 6 with sufficient force to cause the material to penetrate between the laminations or if the resin is otherwise permitted to deposit between the laminations, the laminations may thereby be further bound together. Such a modification is hereinafter explained is discussing FIG. 5 below.

It is not necessary to provide the laminations with special holes 5*a*, 5*b*, 5*c*, etc., for bonding, since the laminations frequently include holes 16 for through bolts (and other purposes) which attach the outer end shields (not shown) to the core. Besides the through bolt holes, if the core is a stator for a dynamoelectric machine of the salient pole type, the laminations will also generally include winding pin holes for the inserting of winding pins used to retain the stator windings in such machines; however, it will be understood that other types of machines may not contain winding pin holes. Such bolt holes, or winding pin holes, or such other holes that may be provided, may be utilized in place of the special rivet holes discussed above. The lamination stack 1 is placed on the mandrel 2 and held in place on the frames 3, 4 as above. The resinous material is now introduced into the holes preferably under a pressure sufficient to force the resinous material to penetrate between the laminations. While it is understood that there is a tendency for the resinous material to be drawn between the laminations due to capillary action a sufficient pressure will materially assist in depositing the resin more satisfactorily. A pressure in the range of 60 lbs. per sq. in. to 1000 lbs. per sq. in. appears satisfactory. The resinous material then penetrates and is deposited between the adjacent laminations and forms a layer between them. Once the penetration has been completed, the pressure can be released and air blown through the holes to clear the holes of excess material; layers of material still remain between the laminations. In this manner, the holes may then be used for their primary function, such as through bolts, winding pins, or the like. The core is then baked as above in the oven 14 and the layers of hardened resinous material disposed between the laminations surrounding the holes will hold the core firmly together. As illustrated in FIG. 4, in the area of the bolt hole 16 the stack consists of alternate layers 1*a*, 1*b*, 1*c*, of laminations and bonding material 13. Thus, each lamination is stuck to the ones adjacent to it without plastic rivets holding the stack together as in the above first described modification.

While in the above preceding modification, the laminations are held together by plastic material between the laminations in the area of the passageway or hole 16, it is not necessary that the excess material be blown from the passageway 16; the core in that area will then be held together by both a plastic rivet and plastic material between the laminations of the area of the passageway. This is illustrated in FIG. 5 wherein plastic material 13 fills the the hole or passageway 6 and further penetrates between the laminations 1*a*, 1*b*, 1*c*, etc., in the area of the hole 6. Thus, each lamination is stuck to the one adjacent to it as well as being held by plastic rivets.

It will be quite obvious that all the modifications, or any combination thereof, may if desired (but it is not necessary), be combined to form a single core structure, as illustrated in FIG. 2. In other words, the resin can be introduced into special rivet holes according to the first above described modification (as illustrated in FIG. 3) and may, in other rivet holes of the same core be introduced with enough force to cause it to penetrate between the laminations (as illustrated in FIG. 5). In other through holes, excess resin may be blown out after some resin is deposited between the laminations, thereby bonding the core by a layer of resin between the laminations. As to the first described modification wherein the laminations are secured by a plastic rivet, some resin will flow between the laminations due to capillary action or as a result of the aforesaid secondary flow characteristic of the resin during curing; therefore, it is likely that the plastic rivets will not be bonding the lamination alone, but will be working in combination with plastic material between the laminations.

If the lamination stack 1 is of a height greater than that needed for a single finished core, the desired core height may be selected and the stack may be divided into a number of core members of the desired height. Such a stack height selection may be accomplished in any well known method, for example, by slicing. The preparation of stacks of laminations of a length long enough for several cores has the further advantage that after curing and bonding, the lamination stack may be placed in storage or may be used for stack height selection as needed. This results in a reduction of core storage space since the rapidity at which the core height may be selected will permit the storage of lamination stacks only and the actual cores may be constructed by the method according to the invention as production thereof warrants.

It will be readily seen that the disclosed method results in the elimination of core keys and rivets and in the elimination of complex core keying and riveting machines. It results in the use of simple, low cost core height selecting methods and permits the reduction of core storage space. It was found that cores made according to the above described method have adequate strength for use in the above mentioned electric inductive devices. While the invention has been described specifically with relation to dynamoelectric machine cores, it is to be understood that the invention can be equally practiced with relation to other electric inductive devices, such as the cores of transformers.

In accordance with the Patent Statutes, I have described what at present are considered to be the preferred embodiments of our invention. However, it will be obvious to those skilled in the art that various changes and modifications may be made in the disclosed structure and method without departing from our invention, and it is, therefore aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. The method of forming a core for an electric inductive device of laminations containing holes therein, comprising the steps of stacking a plurality of said laminations with the holes aligned to form at least one passageway therethrough, introducing heat hardenable resinous material into said passageway under pressure so as to force some of said material to penetrate slightly between the laminations and substantially surround said holes, removing substantially all of the resinous material from said passageway, and hardening the remaining of said material to secure the laminations together.

2. The method of forming a core according to claim 1 wherein the stack is of a height greater than that required for one core, and wherein the method includes the step of dividing the stack into cores of proper height after the resinous material has been hardened.

3. A method of forming a laminated stator core having a bore, winding accommodating means, and a plurality of bolt holes extending axially through the core spaced from said means and positioned adjacent the outer periphery of said core, the method comprising the steps: arranging a plurality of individual laminations in juxtaposed, aligned, relation to form the bore, winding ac-

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commodating means, and bolt holes; introducing a resinous material in an unhardened state under pressure into at least one of said bolt holes while compressing the laminations together so that the material penetrates between adjacent laminations to surround the bolt holes; removing the unhardened material from the bolt holes whereby the bolt holes may be free to accommodate bolts for mounting the stator core; and hardening the material surrounding the bolt holes between the laminations to hold the laminated stack securely together.


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DEFENDANTS' EXHIBIT N.

Sept. 19, 1967 A. E. FEINBERG ET AL 3,341,939

METHOD OF BONDING LAMINATED ELECTROMAGNETIC CORES

Original Filed June 29, 1961

Fig. 1.

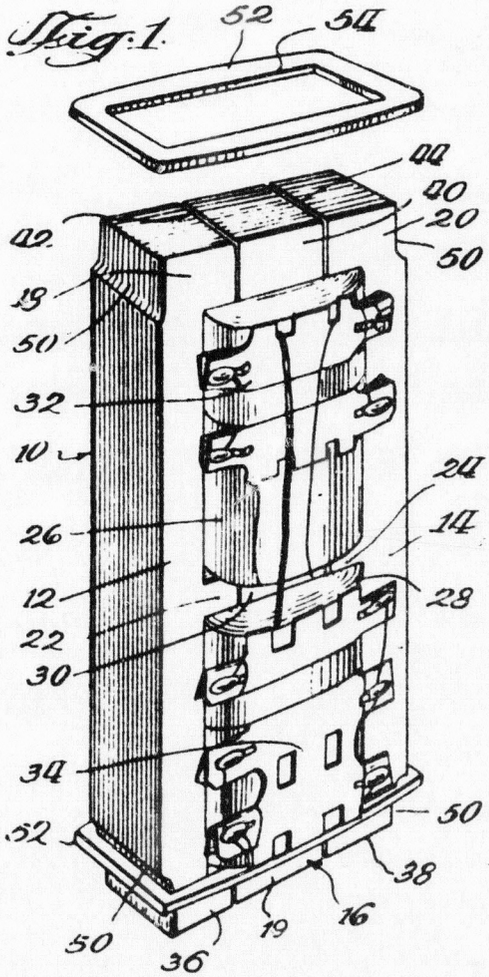



Fig. 2.

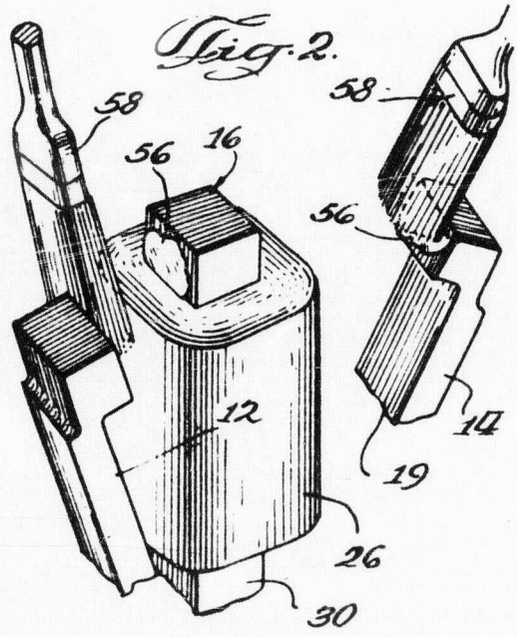



Fig. 3.

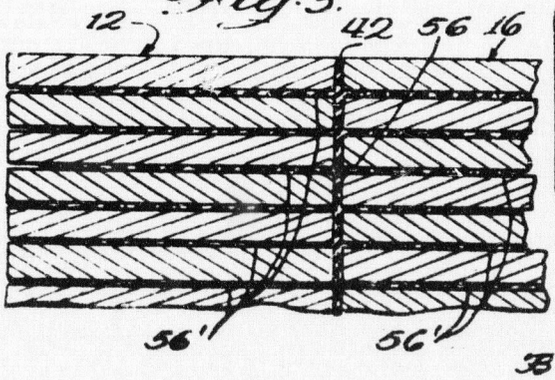
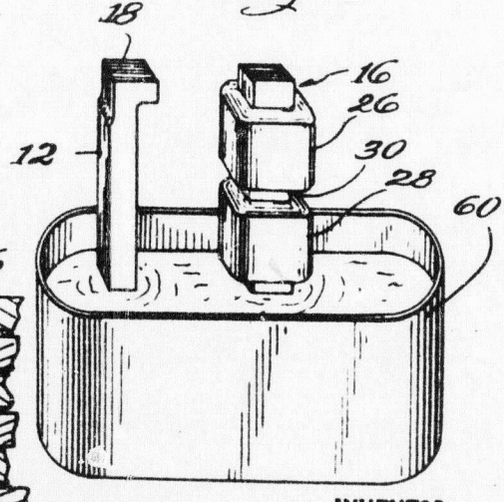



Fig. 4.

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United States Patent Office

3,341,939

Patented Sept. 19, 1967

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3,341,939

# METHOD OF BONDING LAMINATED ELECTROMAGNETIC CORES

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Original application June 29, 1961, Ser. No. 120,656, now Patent No. 3,222,626, dated Dec. 7, 1965. Divided and this application Aug. 19, 1965, Ser. No. 493,297

7 Claims. (Cl. 29—606)

This application is a division of our copending application, Ser. No. 120,656, filed June 29, 1961, now Patent No. 3,222,626 issued Dec. 7, 1965.

This invention relates generally to the art of manufacturing electromagnetic devices such as transformers, and more particularly is concerned with a method of manufacturing the cores for such devices using cementitious bonding media.

The electromagnetic devices with which this invention is concerned comprise iron cores formed of laminated electrical sheet steel, and having coils or windings mounted thereon. The invention herein evolved as a result of investigations directed towards the production of highly economical ballasts for use in gaseous discharge device circuits, but it is believed that the invention has much broader application.

Many transformers used in ballasts for gaseous discharge device circuits are presently formed as shell structures usually of elongate configuration, having an outer rectangular frame-like portion and a central elongate winding leg extending between the bridged ends of the outer frame-like portion. Windings are mounted on the central winding leg disposed in windows formed between the said central winding leg and the side legs of the outer frame-like portion. Such an assemblage is provided with terminal boards or strips providing electrical terminals for the windings and facilitating the connection of the electromagnetic device into a circuit. The core is rigidly held together, and the entire device is usually encapsulated by a suitable potting compound in a metallic canister along with other elements, such as condensers, resistors, etc., with terminal leads protruding from the canister.

The shell type core is quite popular because in recent years it has been possible to manufacture the same from so-called scrapless laminations as taught, for example, in U.S. Patent No. 2,892,249 and others. Such core is formed of stacks of T and L or T and F laminations instead of being formed of laminations of the type shown, for example, in Feinberg Patent No. 2,558,293. In this patent the shell type core is formed of an integral one-piece outer frame portion having the central winding leg frictionally engaged inside the bridging ends. This is a so-called "forced" core.

The problem which has arisen with respect to so-called scrapless variety of electromagnetic cores is that the core is made up of three elongate metallic members, namely the center winding leg which is usually in the form of a T and the outer portions which are usually in the form of L's or F's. Not only is it required that the stacks of laminations themselves be maintained in assembled condition, but likewise it is necessary that the three core parts be held together in some manner by suitable means.

It has heretofore been customary to use a metallic clamp with spring fingers in the form of a cap secured over each end of the core after the windings have been associated thereon, and by such structure mechanically holding the core in assembly.

The use of metallic clamps has been a source of certain disadvantages, especially the production of noise. It is difficult to manufacture the clamps with such structure as rigidly to hold every one of the laminations immovably.

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Variations in dimensions of the laminations result in vibration giving rise to buzzing and humming because of metal contact. There may be many sources for such noise. The stacks of the respective parts may not be the same height; the dimensions of the individual laminations may not be identical; there may be variations in the configuration and resilience of the spring fingers of the clamps; the engagement of the clamps upon the laminations and the laminations upon one another may not be perfect.

Clamps are also quite expensive because they have to be made with highly specialized steels, heat treated for forming spring fingers and using complicated tools and dies. Furthermore, they add to the weight of the ballast. In certain cases, they can cause adverse effects on the magnetic characteristics of a transformer or inductor by providing parasitic paths or undesirable leakage of flux.

The invention herein overcomes all of the objections and disadvantages above enumerated and many others, which will become apparent, by providing a novel method of forming the core for the electromagnetic device using a curable cementitious or adhesive material for bonding the stacks of laminations together, and as well for bonding the respective laminations of each stack one to the other. This comprises an important object of the invention.

The invention has as another object thereof the utilization of a polymerizable resinous material during the formation of a core assembly, said resin's curing or setting cycle is characterized by the presence of an intermediate low viscosity fluid stage to permit said resir to be dispersed, as by capillary action, between each of the laminations of core assembly whereby to serve as a bonding agent therefor in its cured or set state binding all of the laminations in said core assembly into a rigid body, said resin, in its cured state being characterized by high thermal stability.

Still another object of this invention is the provision of a core construction as described above wherein the laminations thereof may be bonded one to the other in a rigid mass to result in a substantial decrease in the noise-forming characteristics of the said core, said bonding agent comprising a polymerizable epoxy resin system which may be temperature or catalytically cured or set and said uncured composition being applied by dipping or brushing onto the edges of said laminations when same are assembled and clamped to form a core construction assembly, said resin being chosen so that a low viscosity intermediate product is formed during the curing or setting thereof thereby introducing, as by capillary action, said bonding agent between the individual laminations, and completing the curing or setting of said resin system to form a substantially permanently bonded unit which remains rigid during subsequent conditions of manufacture and operation.

Still a further object of the invention is the use of a novel clamping member, which is formed of an extremely economical material, such as pressed fiberboard or paperboard used for maintaining the ends of the core in assembly while the cementitious material is setting.

A further object of the invention is to provide a method of making the core structure of an electromagnetic device of the type formed with a laminated core and electromagnetic coils mounted thereon in which, during the course of manufacture, a clamp is used to maintain the core in assembly during the course of manufacture but which clamp readily may be removed and discarded after the core has become a bonded integral structure.

Other objects of the invention will occur to those skilled in this art as a description of the invention herein proceeds, in connection with which the drawings illustrate preferred methods of making the core structure of an electromagnetic device.

In the drawings:

FIG. 1 is a perspective view of an electromagnetic apparatus consisting of a transformer for use in a fluoroscent lamp circuit which has been constructed in accordance with the invention, but the same being illustrated with one of the clamps of the invention disposed in exploded relation to an end of the core.

FIG. 2 is a diagrammatic perspective view showing a method of applying the thermo-setting resinous material to the parts of the transformer core shown in FIG. 1.

FIG. 3 is an exaggerated sectional view showing the manner in which the cementitious material penetrates into the core while it is curing.

FIG. 4 is a diagrammatic perspective view showing another method of applying the cementitious material to the core.

The invention is based in part upon a discovery that certain polymerizable resins having epoxy, polyurethane or equivalent based constituents which are available on the market have unusual bonding powers of sufficient degree to retain steel laminations in assembly. In the shell type of core which utilizes a plurality of core members which must be held together, such resins applied to the abutting laminated end faces and clamped in this association were found not only to result in a bonding together of the clamped members but as well to penetrate between the laminations and cause the individual laminations to be adhered face to face in a compact unitary structure. In order to hold the ends of the core together during the setting of the resin, the invention contemplates the use of a simple rectangular ring of paperboard or fiberboard readily crushable to enable the variations in the lamination dimensions to be accommodated, but yet having sufficient strength to retain the core in assembly while the resin is curing. Such rings or clamps are extremely economical and obviously can be permitted to remain in place upon the ballast or stripped from the ballast and discarded. Such rings are also highly economical and simple to manufacture by merely stamping the same from sheets of paperboard or fiberboard. In the ensuing description a preferred resin or cement of the epoxy or urethane type will be utilized; however, this is not meant to be a limitation of the scope of the invention to such type resin. Even polyester based resins having tensile strength properties so as to solidly adhere the laminations one to the other may suffice.

Referring now particularly to the drawings, FIG. 1 illustrates a transformer **10** which is made up of three parts, a pair of elongate outer F-shaped legs **12** and **14**, and a center T-shaped leg **16**. Each of these three parts is formed of a stack of laminations, the laminations of each respective part being identical in configuration. Obviously it is intended that each of the stacks be of the same height.

The individual laminations of each stack are held together, generally by rivets, as well known in the art. Notwithstanding their assembly in stacks, it must be understood that the individual laminations of a stack are free to move in small increments within the limits of their riveted connection. Such movement takes the form of vibrations the effect of which is highly undesirable operational noise unless the said freedom of movement is eliminated. This phenomena is one which has faced artisans in this art for many years. It also is possible for an operator manually to grasp tightly a number of laminations in juxtaposed aligned relation to form a "stack" i.e. a core part, of sufficient predetermined thickness, and to handle said separate laminations as a single stack for a rather short limited time. Such last mentioned "stacks" can be hand held during the "dipping" or "brushing" step contemplated by the method of the invention without the laminations falling apart from their stacked grouping. These operations are of momentary duration. Hand-holding and/or riveting are well known in the art of manufacturing electromagnetic core and coil assemblies and would be inherently understood by the skilled artisan in this art.

As viewed in FIG. 1, the parts **12** and **14** are arranged with their right angle legs **18** and **20** at the upper end of the view, and the intermediate extensions **22** and **24** forming shunts in a manner well known. The center T-shaped leg **16** has its cross-head **18** at the bottom of the view abutted between the lower ends of the respective side parts **12** and **14** while the major portion thereof comprising the central winding leg **30** of the core passes through a pair of windings **26** and **28** disposed on the said central winding leg in windows which are formed in a manner well known. Suitable terminal boards **32** and **34** are held to the windings by means of adhesive tape or the like and the various connections from the windings **26** and **28** are brought out and soldered to the terminals of the terminal boards.

The lower ends of the side members **12** and **14** are identified by the reference numerals **36** and **38** while the upper end of the central winding leg **30** is identified by the reference numeral **40**. It will be seen that in the assembly of the ballast, the legs **18**, **20** and end **40** are disposed in abutting relationship along two junctures **42** and **44** while a similar arrangement is provided at the bottom end of the core due to the abutting relationship of the ends **36**, **19** and **38**.

For the purposes of describing this view, it may be assumed that the junctures **42** and **44** and the equivalent junctures at the bottom of the core have been provided by bonded and cured epoxy or urethane resin, and that the resulting core structure of the transformer **10** is a unitary assemblage, rigid and immovable, not only with respect to the parts **12**, **14** and **16** but as well with respect to the individual laminations making up the parts. In the course of building the ballast, or electromagnetic device, first the central winding leg **30** will have the two windings **26** and **28** assembled thereto by passing the said central winding leg through the centers of the windings into the tubular paper forms upon which the windings are formed. These two windings are adjusted along the length of the central winding leg with one winding such as winding **28** usually abutting against the cross-head **19** of the T and the other winding **26** spaced sufficiently from winding **28** to be accommodated in the windows which will be formed when the parts of the electromagnetic device are assembled. Thereafter the stacks of laminations forming the side parts **12** and **14** are assembled to the central winding leg over the windings **26** and **28** having previously been treated with the cementitious material, such as the epoxy or urethane resin or cement referred to, and the ends are clamped together.

In order to clamp the ends of the electromagnetic device together during the setting of the epoxy or urethane resin or cement, notches such as shown at **50** are provided at the four corners of the core structure. These notches are no different from those heretofore used in electromagnetic devices which utilized metal clamps. In this case, however, instead of metal clamps, rectangular rings **52** are engaged over each end of the electromagnetic device. These rings **52** may be referred to as "disposable binder means" since they may be disposed of subsequent to cure of the resin as hereinafter described. Each ring has a central recess **54** which fits the assembled core ends, the recess being formed at the same time that the rings are stamped. The recess may be formed slightly smaller in its interior dimensions than the maximum dimensions of the ends of the core. The material from which the rings preferably are made is paperboard or fiberboard of some kind which is crushable so that the ring may be forced on to the ends of the core and will tightly hold the portions of the core as well as the laminations in assembled condition without any danger of movement.

It will be appreciated that the strength of the ring need not be sufficient to enable dependence upon such ring for maintaining the ends of the core in assembled condition

permanently without other means being used. The only function required of the rings in this usage thereof is to maintain assembly until the cement has set or cured, and for this purpose the rings are more than sufficient. The exploded portion of FIG. 1 illustrates the manner in which the ring is installed or removed. An arbor press or ram may be used. The rings may be left in place after the core has been formed, and the cement set or cured, or the rings may be removed if it is desired to keep the size of the core as small as possible and eliminate possible pressure points against lead wires. It is immaterial which. Often the adhesive may run onto the ring and thereby prevent its ready removal in which case it may be left in position.

In applying the epoxy or urethane resin or cement to the portions of the electromagnetic device **10**, several different methods may be used. In FIG. 2, the central T-shaped member **16** and the side members **12** and **14** are shown being painted with the adhesive or cementitious material which is designated **56**, on the abutting surfaces, by means of the brushes **58**. There will be two opposite surfaces or end faces of the end of the member **16** and the end faces of each of the side members **12** and **14** respectively. Obviously similar surfaces at the lower end of the core will be painted with the cement.

In FIG. 4, another method is shown in which the entire end of the core member is dipped into a container of the epoxy or urethane resin or cement such as shown at **60**. When this is done, the windings **26** and **28** or any other windings which are intended to be mounted on the central winding leg are already in position. Obviously the stacks must be held together by some suitable means during this process although it is a simple matter for the workman who is assembling the device to hold the stacks of the side members **12** and **14**, for example, in his hand while this is being done and slip the rings **52** over the ends after the core has been assembled.

One property of the resin suitable here such as the urethanes are epoxy resins has been found to be of great advantage. The epoxy cements as they are used today are of rather viscous consistency and do not run rapidly or readily into the interstices between the laminations. Just before the set or cure, however, the physical properties of the epoxy cement undergo a change which renders them very fluid and penetrating. For the purpose of this description the term "low viscosity" is intended to be interpreted as meaning that the material is characterized by a high degree of flowability. High viscosity is intended to reflect a viscous consistency of low flowability. At this point it has been found that the epoxy cement will penetrate between the tightly held adjacent laminations somewhat as shown in the exaggerated view of FIG. 3, and by capillary action during cure the epoxy cement will be drawn to a great extent transversely almost to the very outer ends of the laminations, thereby providing a very strong bond not only between the two portions which are abutted but as well between the face to face surfaces of the individual laminations. Now the degree of freedom of movement of individual laminations can be substantially reduced upon setting of the resins. We also can say that there is a third stage of the resin upon curing where the resin has zero flowability. In FIG. 3, for example, there is illustrated in section the abutting juncture or joint **42** between the side parts **12** and the central part **16**. The epoxy resin or cement **56** provides a bond between the abutting faces of the parts **12** and **16**, and the epoxy resin or cement **56'** which has run between the surfaces of the individual laminations provides the advantageous assembly of the entire apparatus into an integral structure. The epoxy cement is shown in the view in its cured condition by means of the dark areas between laminations.

It is feasible to use some manner of flexible or extensible member other than the paperboard or fiberboard ring **52** to hold the ends of the core in assembled condition while the epoxy resin or cement is curing. It is preferable that such a member have the property of being able to apply fairly even pressure upon each and every lamination of the assemblage, so that when the cure occurs, there will be no misplaced laminations or air spaces. It is believed that there has been no successful bonding of the ends of electromagnetic devices comprising laminated cores with such thermo-setting resins.

It is also desired to point out that other cementitious or bonding materials may be used advantageously with the rings **52** and that after such cementitious materials have set, the entire assemblage **10** may be impregnated with varnish and baked and/or encapsulated in some plastic or potting compound, thereby adding overall rigidity to the assemblage and relieving some of the strain from the rings **52**. Under such conditions, of course, it is intended that the rings will remain in position on the completed electromagnetic device.

The retaining rings **52** instead of being made of paperboard and fiberboard may in ceertain instances be of a semi-permanent nature, being made of synthetic resins, such as nylon or other plastics, which while to some extent yieldable nevertheless have great strength. The yieldability, on the interior of the ring at least, is to accommodate variations in stock size and lamination dimensions. Whether of paperboard, fiberboard or plastic, the ring should be able to withstand the temperatures to which the electromagnetic device may be subjected before the adhesive has set or is cured.

In using the method of the invention, the curing of the cementitious or resinous material may take place in several ways. It may be permitted to take place in air; it may be accelerated by baking in an oven; it may occur as a result of "potting" with no potting compound; it may occur simultaneously with another procedure such as varnishing and/or baking the varnish.

Although many resins are suitable for use with the invention, it is preferred to utilize those of the group epichlorohydrin bisphenol-A which has been catalyzed by an acid anhydride. To speed the curing or setting of the resin system, a small amount of an accelerator may be added, such as for example, a tertiary amine, or commercially available dimethylamino methyl-phenol, tridimethyl amino methyl phenol, and the like.

An exemplary formulation was successfully utilized to prepare a core of the character described. Such formulation as described below is to be considered solely for the purpose of illustrating the practice of the invention and in no matter is to be considered as a limitation to the scope of the invention as described in the claims appended hereto.

The successful formulation was as follows:

10 parts epoxy resin of the bisphenol A-epichlorohydrin type
6 parts hexahydrophthallic anhydride
1 part tridimethyl amino methyl phenol (DMP30)

The core laminations were assembled into stacks to form the core parts and subsequently assembled to form the core construction after the coating step. The composition was brushed at the edges thereof. The clamp rings were placed on opposite ends of the core assembly. The core assembly with the brushed-on coating was exposed to 135° centigrade for 50 minutes in an oven. When the core assembly was removed from the oven, the resinous composition was found to be cured and had become a rigid mass. The clamping rings were then removed and the assembly was held intact by the polymerized resinous composition. On subsequent testing and operation the finished transformer core was found to be operative with less production of noise. The core was subsequently taken apart and the residual evidence showed that the resin had entered the space between the tightly held juxtaposed laminations and had firmly bonded same together.

Obviously variations in the methods and structures can be made without departing from the spirit or scope of the invention.

DEFENDANTS' EXHIBIT N





What it is desired to secure by Letters Patent of the United States is:

1. In a method of manufacturing cores for mounting electromagnetic coils thereon to form electromagnetic devices wherein said cores include outer winding legs and a center winding leg, each formed of a stack of a predetermined number of individual lamination parts of size and configuration to form said legs and in which the method includes the steps of assembling the individual parts into stacks to form the outer winding legs and a central winding leg and assembling said so-formed winding legs with the electromagnetic coils mounted thereon to form said core construction by placing end portions of said outer winding legs abutting adjacent end portions of said central winding leg; the invention comprising the steps of applying an exterior coating of a polymerizable resinous composition at a first viscosity stage of low flowability to the abutting portions of said winding legs prior to their assembly to form said core construction, placing disposable binder means over the ends of said assembled winding legs and spaced from said ends, and thereafter, with the disposable binder means so placed, curing said resinous composition to an intermediate viscosity stage of high flowability to introduce, as by capillary action, between juxtaposed individual lamination parts and thereafter completing the cure of said resinous composition to a cured viscosity stage of zero flowability whereby said laminations are permanently bonded.

2. The method as claimed in claim 1 in which said disposable binder means are removed subsequent to the completion of curing of the resinous composition.



3. The method as claimed in claim 1 in which the composition is chosen from the group comprising epoxy resins and same is cured by heating.

4. The method as claimed in claim 1 in which said composition is chosen from the group comprising epoxy resins and includes an acid anhydride activator.

5. The method as claimed in claim 1 in which said composition is chosen from the group comprising epoxy resins and includes an acid anhydride activator and an accelerator.

6. The method as claimed in claim 1 in which said composition is applied by means of dipping said winding legs partially into said composition.

7. The method as claimed in claim 1 in which said composition is applied by means of brushing the coating along the said abutting portions of said winding legs.


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CHARLIE T. M[illegible]ON, *Primary Examiner.*

R. W. CHURCH, *Assistant Examiner.*

# UNITED STATES PATENT OFFICE

# CERTIFICATE OF CORRECTION

Patent No. 3,341,939 September 19, 1967

Albert E. Feinberg et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 7, for "18" read -- 19 --; column 5, line 38, for "resin" read -- resins --; line 39, for "are" read -- or --; column 6, line 19, for "ceertain" read -- certain --; line 55, for "1" read -- .1 --.

Signed and sealed this 15th day of October 1968.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents

DEFENDANTS' EXHIBIT O.

# United States Patent Office

3,065,571
Patented Nov. 27, 1962



3,065,571
COMPOSITE MATERIAL OF PLATINUM ALLOY AND GLASS

James S. Hill, Cranford, N.J., assignor, by mesne assignments, to Engelhard Industries Inc., Newark, N.J., a corporation of Delaware

No Drawing. Filed Oct. 10, 1957, Ser. No. 689,262
6 Claims. (Cl. 154—2.4)

The present invention is concerned with the problem of obtaining a mechanically-resistant, air-tight bond between metal and glass and, more specifically, of obtaining air-tight metallic seals through glass as e.g. electrical lead-in conductors into glass containers.

In numerous industrial fields, the necessity to obtain such bonds occurs, as e.g. in apparatus for the electro-chemical industry, electrical discharge devices, electrical contacts and so forth, and the attempts to improve the adherence of metal to glass, which usually is bonded thereto in its molten state, include the application of specific methods of cleaning the contacting surfaces, the use of certain pressures, temperatures and even of certain atmospheres surrounding the parts to be bonded at the moment of contacting the components and during the cooling off period.

The present invention is concerned with a new approach to the problem which consists in utilizing the wetting power of a liquid.

The free surfaces of liquids show the phenomenon called capillarity which is caused by the specific surface tension of the liquid on one hand and, on the other hand, by the inter-molecular affinity of the liquid to the solid wall material of the capillary. The resultant of the components may either cause the liquid to wet the solid surface, which might be a capillary or merely a surface in contact with the liquid, or, in the opposite case, repulsion can take place.

Assuming that molten glass represents a liquid and that the bond formed between any surface in contact therewith must be tighter if the inter-molecular affinity between them results in a positive wetting action, numerous tests were made with alloys and thereby it was found that an alloy of about 90 percent to 99.9 percent by weight of platinum and about 10 percent to 0.1 percent by weight of silver shows an affinity for molten glass which results in a wetting action which is superior to the metals or alloys used heretofore. By applying the customary methods of bonding molten glass to the preformed metallic portions of the aforementioned alloys, the inter-molecular attraction contributes greatly to the improvement of the obtained bond.

In accordance with the invention, the metallic portion, e.g. a lead-in conductor for an electrical discharge tube, is pre-shaped from an alloy of about 90 percent to 99.9 percent by weight of platinum and about 10 percent to 0.1 percent by weight of silver. Preferably an alloy of about 95 percent by weight of platinum and



about 5 percent by weight of silver is used, which was found to give best results. Subsequently, the bonding of the metallic portion to the glass portion is performed according to any of the known methods, e.g. for lead-in seals by applying, simultaneously, heat to melt the glass and pressure within a mold to give the lead-in seal the desired shape.

The term glass, as used herein, includes porcelain and quartz glass as well since these materials behave in a similar manner.

It will be obvious to those skilled in the art that many modifications may be made within the scope of the present invention without departing from the spirit thereof, and the invention includes all such modifications.

What is claimed is:

1. A composite material comprising glass bonded to an alloy of about 90 percent to 99.9 percent by weight of platinum and about 10 percent to 0.1 percent by weight of silver.

2. A composite material comprising glass bonded to an alloy of about 95 percent by weight of platinum and about 5 percent by weight of silver.

3. A metallic seal through and bonded to glass wherein the metal is an alloy of about 90 percent to 99.9 percent by weight of platinum and about 10 percent to 0.1 percent by weight of silver.

4. A metallic seal through and bonded to glass wherein the metal is an alloy of about 95 percent by weight of platinum and about 5 percent by weight of silver.

5. An electrical conductor through and bonded to glass made from an alloy of about 90 percent to 99.9 percent by weight of platinum and about 10 percent to 0.1 percent by weight of silver.

6. An electrical conductor through and bonded to glass made from an alloy of about 95 percent by weight of platinum and about 5 percent by weight of silver.

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BEST COPY AVAILABLE

DEFENDANTS' EXHIBIT P.

DEUTSCHE DEMOKRATISCHE REPUBLIK

AMT FÜR ERFINDUNGS- UND PATENTWESEN

K

# PATENTSCHRIFT Nr. 10546

KLASSE 42g GRUPPE 10/01 AKTENZEICHEN WP 42g/23116

## Verfahren zum Verkleben von lamellierten bzw. aus Folien zusammengesetzten Gegenständen, insbesondere von Magnetköpfen

Erfinder
zugleich SIEGFRIED LIETZ, Berlin
Inhaber:

Patentart: Deutsches Wirtschaftspatent

Patentiert in der Deutschen Demokratischen Republik ab 12. Februar 1953

Tag der Ausgabe der Patentschrift: 26. September 1955

Die Erfindung betrifft ein Verfahren zur Herstellung von aus Lamellen bzw. aus Folien zusammengesetzten Gegenständen, insbesondere von Magnetköpfen, bei dem die Lamellen mittels Verklebung und Trocknungs- und Backprozeß zu einem kompakten Körper vereinigt werden. Bisher hat man die einzelnen Folien bzw. Lamellen ausgelegt und das Klebemittel aufgespritzt. Nach Antrocknung der einen Seite mußte derselbe Arbeitsgang mit der zweiten Seite erfolgen. Nach erneutem Antrocknen wurden die Lamellen zu der gewünschten Stärke des Magnetkernes geschichtet und durch einen Preß- und Backprozeß in den kompakten Magnetkern umgewandelt. Dieses Verfahren war sehr zeitraubend, außerdem erforderte es einen starken Verbrauch an Klebemittel.

Eine wesentliche Vereinfachung bei der Herstellung solcher Magnetköpfe ergibt sich bei Anwendung der Kapillarwirkung erfindungsgemäß dadurch, daß die übereinandergeschichteten und fest zusammengehaltenen Lamellen bzw. Folien in ein Klebemittel getaucht werden. Dadurch wird die für die Herstellung der Magnetkerne benötigte Zeit wesentlich verringert und es wird nur soviel an Klebemittel verbraucht, wie für die Benetzung der Lamellen erforderlich ist. Außerdem ist die Möglichkeit der Automatisierung gegeben.

In der Zeichnung ist ein Ausführungsbeispiel der Erfindung dargestellt.

Die Abb. 1 zeigt den lamellierten Magnetkopf (die Wickelungen sind nicht gezeichnet) eines Magnettongerätes. Gemäß dem erfindungsgemäßen Verfahren wer-

DEFENDANTS' EXHIBIT P

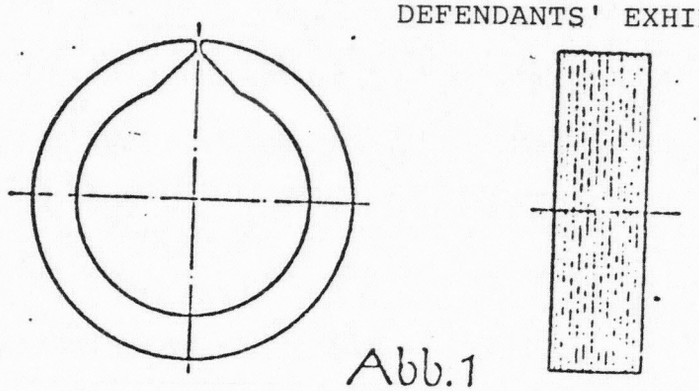

Abb. 1

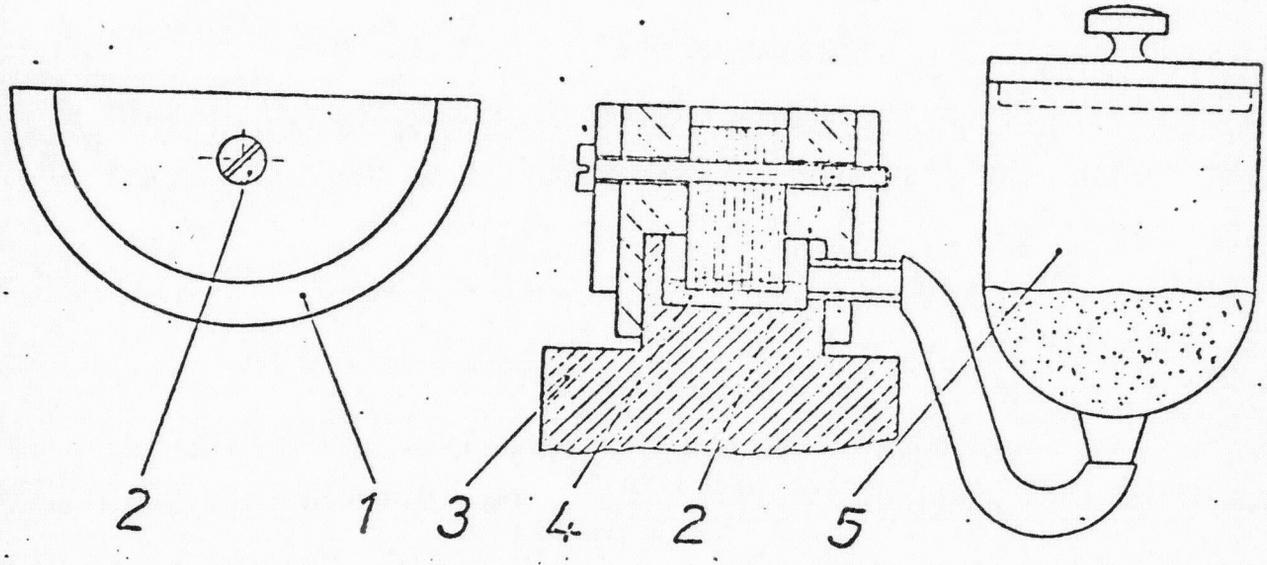


Abb. 2

den die einzelnen Lamellen (nach Abb. 2) von einer Klemmvorrichtung 2 zusammengehalten. Mit dieser Vorrichtung wird das Lamellenpaket in das in dem Behälter 3 befindliche Klebemittel 4 getaucht. Dieses steigt in den Kapillarspalten zwischen den Lamellen hoch. Das Klebemittel befindet sich in einem Vorratsbehälter 5, so daß in dem Tauchbehälter 3 immer das gleiche Niveau herrscht, so daß der Tauchvorgang weitgehend automatisiert werden kann.

Das mit dem Klebemittel vollgesaugte Lamellenpaket wird mit der Klemmvorrichtung danach einem Trocknungs-, Preß- und Backprozeß unterzogen. Die beiden Hälften des in Abb. 1 gezeigten Kopfes werden nach Schleifen des Luftspaltes mittels Kalibern und Aufbringen der Spulen zu dem kompletten Kopf zusammengestellt.

*Patentansprüche:*

1. Verfahren zum Verkleben von lamellierten bzw. aus Folien zusammengesetzten Gegenständen, insbesondere von Magnetköpfen unter Verwendung der Kapillarwirkung, dadurch gekennzeichnet, daß die übereinandergeschichteten und fest zusammengehaltenen Lamellen bzw. Folien in ein Klebemittel getaucht werden.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß das von der Klemmvorrichtung gefaßte Lamellenpaket einem Trocknungs-, Preß- und Backprozeß unterzogen wird.

**TRANSLATION** DEFENDANTS' EXHIBIT P

from: GERMAN

German Democratic Republic

Office for Inventions and Patents

PATENT No. 10,546

Class 42g, Group 10/01, Serial No. WP 42g/23116

METHOD OF BONDING LAMINATED OBJECTS OR OBJECTS COMPOSED OF SHEETS, AND PARTICULARLY MAGNETIC HEADS

Inventor and owner: Siegfried Lietz of Berlin

Type of patent: German economic patent

Patented in the German Democratic Republic as from February 12, 1953

Date of publication of the patent: September 26, 1955

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The present invention relates to a method of manufacturing objects composed of laminations or sheets, particularly magnetic heads, in which the laminations are combined by bonding and a drying and baking process to form a compact body. Up to now the individual sheets or laminations have been laid out and the adhesive sprayed thereon. After the drying of the one side therefore the operation had to be carried out with the other side. After again drying, the laminations were stacked to form the desired thickness of the magnetic core and converted by pressure and firing in the compact magnetic core. This method was very time-consuming and it furthermore required a large amount of adhesive.

**TRANSLATION** DEFENDANTS' EXHIBIT P

*from:* -2-

A substantial simplification in the manufacture of such magnetic heads is obtained in accordance with the invention with the use of capillary action in the manner that the laminations or sheets which are stacked one above the other and held fast are dipped into an adhesive. In this way the time required for the manufacture of the magnetic cores is substantially reduced and only as much adhesive as required for the wetting of the laminations is consumed. Furthermore, the possibility of automated operation is present.

One embodiment of the invention is shown by way of example in the drawing.

Fig. 1 shows the laminated magnetic head (the windings have not been shown) of a magnetic recorder. In accordance with the method of the invention, the individual laminations (in accordance with Fig. 2) are held together by a clamping device 2. The package of laminations is dipped together with this device into the adhesive 4 which is contained in the container 3. The adhesive rises up in the capillary gaps between the laminations. The adhesive is contained in a storage tank 5 so that the same level is always present in the dip container 3 so that the dipping process can be made substantially automatic.

The bundle of laminations which is fully permeated with the adhesive is subjected thereupon together with the clamping device to a drying, pressing and firing process. The two halves of the head shown in Fig. 1 are assembled to form the complete head after grinding of the air gap by means of gauges and

TRANSLATION DEFENDANTS' EXHIBIT P

from: -3-

application of the coils.

CLAIMS

1. Method of bonding laminated objects or objects composed of sheets, and particularly magnetic heads, with the use of capillary action, characterized by the fact that the laminations or sheets which are stacked one above the other and held firmly together are dipped into an adhesive.

2. Method according to Claim 1, characterized by the fact that the bundle of laminations held together by the clamping device is subjected to a drying, pressing and firing process.

**TRANSLATION** DEFENDANTS' EXHIBIT R

*from:* GERMAN WB:dm

From: ZINCKE, "TECHNOLOGIE DER GLASVERSCHMELZUNGEN," Leipzig, 1961, page 169

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P. 169. 7.3 Forms of ceramic/metal solderings.

..... An elastic metal equalization ring which is soldered on one side to the ceramic and on the other side to the metal parts takes up the stresses (Fig. 831). This technique is ....

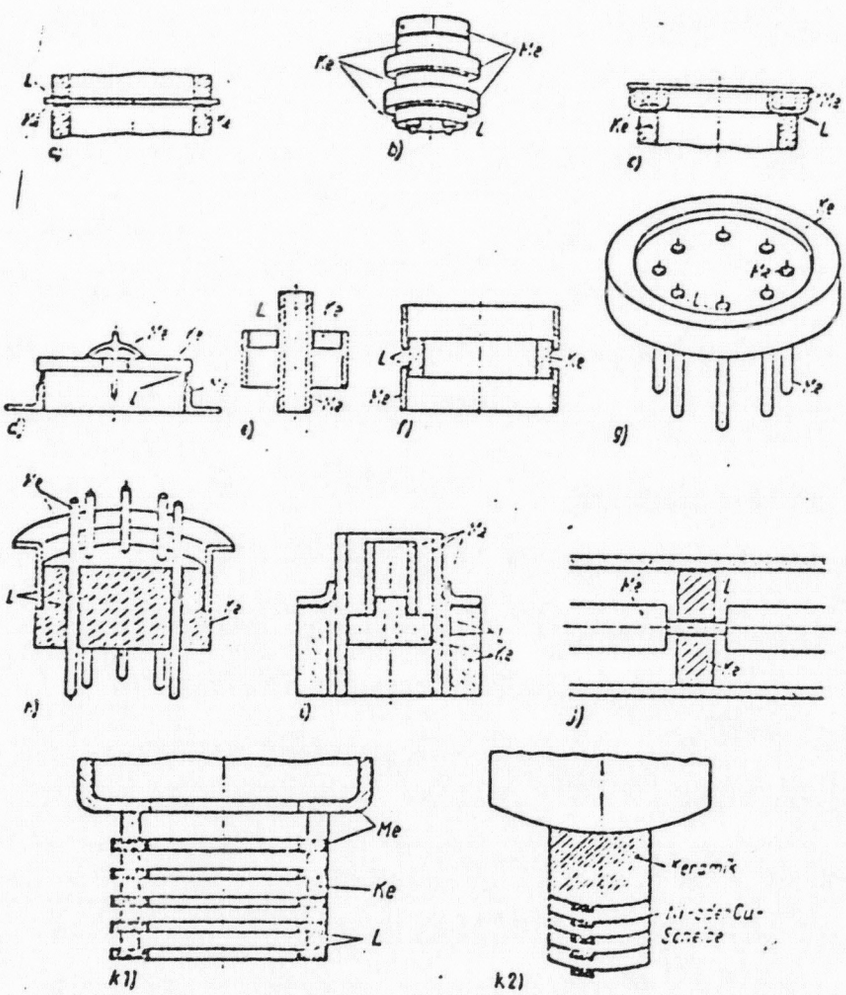


Fig. 84. Multiple metal/ceramic solderings.

a,b,c,d: Multiple butt solderings; e, f: multiple

**TRANSLATION**

*from:* DEFENDANTS' EXHIBIT R

cylindrical solderings; g: Disk-foot by butt soldering; h: Disk foot by cylindrical soldering; i: Combination of butt and cylindrical solderings; j: Ceramic window with outer and inner cylindrical soldering; k: Tube with multiple disk leadthroughs. (Ke, Me, L, see Fig. 83).

I - Ceramic
II - Ni or Cu disk

**TRANSLATION**

*from:* DEFENDANTS' EXHIBIT R

pages 176, 177

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7. Hermetic Ceramic/Metal Solderings in Electrical Engineering

7.4 Production of Ceramic/Metal Solderings

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3. The solder places must be protected from oxidation during the heating. This is effected either by the solder or flux or in an inert gas atmosphere. In this way the dissolving, volatilization, reduction or slagging of oxides present is obtained.

One distinguishes between soft soldering and hard soldering (brazing). The difference lies essentially in the soldering temperature (see page 163). Solderings below 450°C are referred to as soft solderings, and solderings above 450°C hard solderings. The latter are generally so-called gap solderings.

In gap soldering, the workpieces to be connected must form gaps which have approximately parallel walls and are relatively narrow and the width of which at the time of soldering generally does not exceed 0.5 mm. The molten solder is drawn by the capillary forces into the gap, the walls of which are at operating temperature. This type of soldering which is characteristic of hard soldering (brazing) is preferred in ceramic/metal solderings.

**TRANSLATION**

*from:* DEFENDANTS' EXHIBIT R

Table 12

Guide values for gap size (in accordance with literature reference 40)

| Solder | Gap width (mm) for basic materials | | |
|---|---|---|---|
| | Light metals | Steel materials | Nonferrous heavy metals |
| LA1Si | 0.15-0.6 the longer the seam, the wider the gap | - | - |
| Copper | - | 0-0.1 on steel; 0.25-0.4 when soldering steel-hard metal | - |
| Brass solder | - | 0.05-0.25 | 0.1-0.4 |
| Copper-phosphorus solder | - | - | 0.1-0.3 |
| Silver-copper-phosphorus solder | | | 0.05-0.2 |
| Silver solder | - | 0.02-0.15 | 0.05-0.25 |
| Soft solder | 0.2 | 0.1 | 0.1-0.2 |

For the proper effecting of the soldering there must be assured the proper dimensioning of the gap width, a favorable nature of the surface of the walls of the gap and suitable shapes of the workpieces which are to be bonded. The size of the gaps is limited in upward direction by the termination of the capillary action and in downward direction by the difficulty in passage of the solder.

**TRANSLATION**

*from:* DEFENDANTS' EXHIBIT R

The ultimate strength of the solder bonds increases with decreasing width of gap. Below a given, very low value (see Table 12), it, however, rapidly decreases again. The decisive factor is not only the absolute size of the gap width, but also the ratio of the width of the solder gap to the solder area: as the ratio becomes smaller, the ultimate strength of the bond increases. The dimensions of the solder surfaces which still permit sufficiently strong bonds are therefore restricted by the permissible maximum values of the width of the solder gap.

The selection of the gap is determined also by the solder. Copper, for instance, flows better in a reductive atmosphere through the gap than brass and aluminum hard solders do. In the case of copper, therefore, the gap can be narrower than with the last-mentioned metals, and it even penetrates the gap between parts which are inserted together with a force fit. Table 12 gives a few guide values for gap sizes.

The gap surfaces must be approximately parallel, since a widening of the gap reduces the capillary action and can cause the flow of the solder to come to a stop. Constrictions in the gap are not as injurious as widenings; nevertheless they are to be avoided insofar as possible, since the speed of flow is reduced. In general a smooth surface of the gap is desirable. It results in higher strength values, but has a poorer wettability. Scorings and depressions which extend perpendicular to

the direction of soldering are extremely injurious. Those which lie in the direction of soldering on the other hand promote the flow of the solder and are at times intentionally provided.

Fig. 87 shows by means of a few examples how a proper solder connection looks and gives a few forms of solder connections which show favorable stress conditions. In addition, a few unfavorable forms have been shown by way of comparison.

Overlaps (Fig. 87c) should not be longer than three to four times the thickness of the thinnest part of the workpiece to be bonded. By an increase in the solder surface, with increasing consumption of solder, the strength is not increased.

Hard solderings are preferably carried out in an inert gas furnace. In this case, additional flux is dispensed with. As inert gases, hydrogen and noble gases are employed. The furnaces are .....

**TRANSLATION**

*from:* DEFENDANTS' EXHIBIT R

page 192

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**TRANSLATION**

*from:* DEFENDANTS' EXHIBIT R

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554a

DEFENDANTS' EXHIBIT T.

PLAINTIFF'S EXHIBIT 1 FOR IDENT.
BORAK REPORTING SVC.

7 FEB. 1962

Nr. 92

KERAMISCHE FABRIEK

Aanmeldingsformulier voor een uitvinding.

Na(a)m(en) uitvinder(s): H.P.Peloschek en M.H.M.Vrolijks

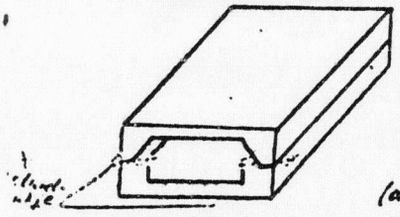
Datum van aanmelding: 1 februari 1962

Korte aanduiding van uitvinding: Het maken van emaillespleten voor magnetofoonkoppen met behulp van capillair inzuigen.
Eerste gegevens over uitvinding in waarnemingsboek: Microspleetkernen - Vrolijks
Datum: december 1961

Beschrijving van uitvinding:
Voor verschillende typen magnetofoonkoppen is het noodzakelijk, om een "luchtspleet" van 1 à 20μ (afmeting afhankelijk van de toepassing) te maken, die een redelijke slijtvastheid en bewerkbaarheid bezit. De hierbij aangemelde methode is de volgende: (zie ook schets)

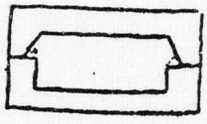
1) De gewenste spleetlengte wordt ingesteld met afstandstukjes (b.v. metaalfolie of mica-plaatjes)
2) Aan een zijde van de spleet wordt een overmaat emaille aangebracht (als frit, poeder of massief draadje)
3) Deze samenstelling wordt in een oven verhit, totdat het emaille smelt, door de capillaire werking wordt de spleet volgezogen met emaille. Het blijkt nodig te zijn een lichte druk aan te brengen om te voorkomen, dat emaille ook tussen afstandstukje en ferrietprofiel kruipt.
4) Na afkoelen is een massieve spleet verkregen van de gewenste dikte, die tevens aan de verlangde eigenschappen qua bewerkbaarheid en slijtvastheid voldoet. Het blijkt, dat de bevochtiging van het ferriet door de gesmolten emaille aanzienlijk verbeterd wordt als het ferriet (waarvan de spleetvlakken i.v.m. de scherpe maateisen geslijpt moeten zijn) na het polijsten op 800° à 1000° verhit wordt.

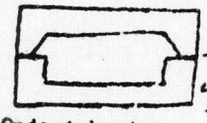
A Aanzicht



C Ferriet-profielen & emaille (draadje-poeder of frit)

D Doorsnede voor en na de temperatuur-behandeling





Ondertekening:
H.P.Peloschek
M.H.M.Vrolijks

Onder deze streep bij aanmelding niets invullen.

Uitvinding wordt: doorgezonden naar Octrooiafd. / aangehouden voor nader onderzoek / niet doorgezonden naar Octrooiafd.

Datum van indiening:

Inleveren bij: Drs. Verschoor, Ideona Ker. Lab.

DEFENDANTS' EXHIBIT T

**TRANSLATION**

VROLIJKS EXHIBIT 1A FOR IDENT. 6/3/65 BORAK REPORTING SVC.

from: Netherlands WB:daf 10/6/1

CERAMIC FACTORY

Application form for an invention

Name of inventors: H.P. Peloschek and M.H.M. Vrolijks

Date of application: February 1, 1962

Title: THE PRODUCTION OF ENAMEL GAPS FOR MAGNETIC TAPE RECORDERS WITH THE AID OF CAPILLARY SUCTION

First information concerning invention in notebook:

Microgap cores - Vrolijks

Date: December, 1961

Description of invention:

For different types of magnetic tape recorders it is necessary to provide an "air gap" of 1 to 20 μ (size dependent on the use) which has a reasonable resistance to wear and machine ability. The method for which application is made here is as follows: (see also sketch).

1) The desired length of gap is adjusted by means of spacers (for instance metal foil or mica plates).

2) On one side of the gap there is provided an excess of enamel (as frit, powder, or solid wire).

3) This composition is heated in a furnace until the enamel melts; as a result of capillary action the gap is filled with enamel. It appears necessary to apply a slight pressure in order to prevent the enamel from also creeping between the spacer and the ferrite profile.

4) Upon cooling there is obtained a solid gap of the desired thickness which also satisfies the required properties

**TRANSLATION** DEFENDANTS' EXHIBIT T

*from:* -2-

with respect to machinability and resistance to wear. It is found that the wetting of the ferrite by the molten enamel is substantially improved if the ferrite (the gap surfaces of which must be polished in view of the high demands as to size) is heated to 800 to 1000° after the polishing.

(Translator's note: see original for sketch.)

A. Outside view

B. Spacer

C. Ferrite Profiles

D. Cross section

E. Before
F. After } the temperature treatment

G. Enamel (wire / powder, or frit)

Invention forwarded to Patent Dept.

DEFENDANTS' EXHIBIT U.

Minutes of Contact-Meeting Research Labs-Glass Labs-Ceramic Labs of date of December 21, 1961

Subject: Gap-techniques for magnetic heads.

Present: Messrs. Boter, Haaijman, Padmos, Peloschek, deRooy, Stuyts, Troelstra, Veenemans, Vrolijks, Wijnen.

The following points have been discussed.

1. Floating 8-Track Head for "Holland Signaal" - (Hosa-head)

At the production of a series of these heads, many difficulties have been encountered. The largest problem is that these heads became un-flat.

In the original design, a number of changes have been introduced (amongst other mu-metal shielding plates) by which the probability of "working" of the epoxy has become larger.

The conclusion is, that for a new series of heads, the design should be changed and contact should be made with epoxy experts to decrease the probability of working of the epoxy.

2. Survey of various gap techniques investigated

a. Elma (Apparatus-Factory). Here a large number of methods have been investigated. The most important results were:

1. CuAg - foil - 1, 5 micron-gap, life test 1500 hours, 4 3/4 cm/sec, loss in output 5 dB.
2. Glass gaps investigation not proceeded, as the reproducibility in gap length was inadequate.

DEFENDANTS' EXHIBIT U

3. Enamel gaps are presently being applied for video heads: life test 21 hours - 25 m/sec. tape speed - after that, still good.
4. For audio-heads presently is being thought about gaps of enamel-metal-enamel.

b. Group Duinker (Research Labs.):
   1. Enamel gaps (enamel provided by sedimentation). Gap length good, but probably due to not-matched enamel-many cracks.
   2. Large number of metal gaps (various alloys), results: varying success.
   3. Combination enamel-metal-enamel as gap material. This is looking promising.

c. Group Troelstra (Research Labs.):
   1. Enamels: Provided by sedimentation, with foils and wires of enamel powders and organic binders. The enamels had not been matched. Therefore, the results were difficult to evaluate.
   2. Glass Ribbon: With glass ribbon made in the glass workshop, Research Labs fine glass gaps have been made. This ribbon can easily be handled, and according to Boter it can be made accurately on thickness. As with the bonding, no pressure and no spacers are required - working with this glass ribbon looks very attractive.

DEFENDANTS' EXHIBIT U

Boter and Peloschek will, if required, contact the Glass Labs (La Grouw), for further experiments (glass slivers of matched glass).

For possible future control of pulling speeds and temperature, advice can be obtained at the group of Mr. Cupido (glass lab.).

d. Ceramic Labs

1. Glass Foils. With blown glass foils of which the thickness is equal to the required gap length, gaps can be made within the required dimensional tolerance, but the quality varies strongly (from large to small amount of bubbles).

Disadvantages:

1. Quality.
2. Very difficult to blow glass foils with the correct thickness in reasonable quantities.
3. Foils not flat, difficult to handle.

2. Glass Fibers

For small bonding surfaces ($\leq$ 1 mm), it is possible to make glass gaps of good quality. To set accurately the gap length, good spacers are necessary, preferably metal foils.

DEFENDANTS' EXHIBIT U

3. Enamel Gaps

The best results regarding gap quality have been obtained by capillary suction of fluid enamel. For the setting of the gap length are then accurate spacers required.

Therefore in the future, metal foils will be used as spacers.

4. Enamel-Metal-Enamel

Experiments with this will be carried out within a short time.

As for various techniques, which have to be investigated, metal foils with small tolerances on the foil thickness will be necessary, Mr. Shuyts will investigate what are the possibilities in the range of about 2 and 6 microns.

Icoma Ceramic Lab

January, 1962/jmr

M. Vrolijks

561a

DEFENDANTS' EXHIBIT NN.

June 26, 1970

170-2-39

Mr. Robert Green, Esquire
Burroughs Corporation
P.O. Box 1226
Plainfield, New Jersey 07061

Dear Mr. Green:

I enclose herewith copy of Schedule A of patents that we own or have license rights under in the field of magnetic heads, under which we are offering licenses to the industry.

If you have any questions, please do not hesitate to contact me.

Very truly yours,

Jack Oisher

:cjb
Enc.

500002

DEFENDANTS' EXHIBIT NN

SCHEDULE A

SCHEDULE OF PATENTS TO BE LICENSED

IN ACCORDANCE WITH ARTICLE II, SECTION 3

GROUP I PATENTS

| PATENT NO. | ISSUE DATE | INVENTOR | TITLE |
|---|---|---|---|
| 2,809,237 | Oct. 8, 1957 | F. Bergmann | Magnetic Sound Recording Head |
| 3,024,313 | Mar. 6, 1962 | S. Duinker et al | Glass Gap Spacer for Magnetic Heads |
| 3,145,453 | Aug. 25, 1964 | S. Duinker et al | Method of Producing Magnetic Heads with Bonding Glass Gap Spacers |
| 3,246,383 | Apr. 19, 1966 | H. Poloschek | Method of Manufacturing Magnetic Heads with Bonding Gap-Filling Materials |

GROUP II PATENTS

| | | | |
|---|---|---|---|
| 2,870,266 | Jan. 20, 1959 | W. Westmijze | Annular Magnet Head of the Kind Comprising a Solid Core for Magnetic Recording and Reproduction |
| 2,907,834 | Oct. 6, 1959 | S. Duinker | Magnetic Reproducing Head |
| 3,126,615 | Mar. 31, 1964 | S. Duinker | Method of Manufacturing Multiple Magnetic Heads |
| 3,094,772 | June 25, 1963 | S. Duinker | Method of Producing Magnetic Heads with Accurately Predetermined Gap Heights |
| 3,249,700 | May 3, 1966 | S. Duinker et al | Magnetic Heads with Means for Preventing Side Erosion |
| 3,249,987 | May 10, 1966 | S. Duinker | Method of Manufacturing Magnetic Heads |



500003

DEFENDANTS' EXHIBIT NN

GROUP PHI PATENTS

| PATENT NO. | ISSUE DATE | INVENTOR | TITLE |
|---|---|---|---|
| 2,700,073 | Jan. 18, 1955 | D. Kleis et al | Head of Equipment for Magnetic Recording and Reproduction |
| 2,822,533 | Feb. 4, 1958 | S. Duinker et al | Device for Reading Magnetically Recorded Memory Elements |
| 2,854,524 | Sept. 30, 1958 | J. Went et al | Apparatus for Magnetically Recording on a Carrier of Magnetic Material |
| 2,870,267 | Jan. 20, 1959 | S. Duinker et al | Arrangement for Scanning and Reproducing Magnetic Fields |
| 2,897,283 | July 28, 1959 | J. Wijchman | Device for Adjusting the Air-Gap Position of Magnetic Heads |
| 2,912,516 | Nov. 10, 1959 | J. Hallmann | Tape Guiding Device |
| C,012,104 | Dec. 5, 1961 | D. Kleis | Method of Recording and Apparatus for Recording Signals |
| 3,058,200 | Oct. 16, 1962 | S. Duinker et al | Method of Orienting in Coplanar Arrangement the Gaps of a Plurality of Magnetic Heads |
| 3,081, 382 | Mar. 12, 1963 | W. Westmijze | Transversely Scanning Transducer with Fixed Electromagnet and Moving Pole Pieces |
| 3,102,170 | Aug. 27, 1963 | C. De Koning | Device for Selectively Erasing Two or More Adjacent Magnetic Tracks of a Magnetic Tape |
| 3,105,286 | Oct. 1, 1963 | S. Duinker et al | Method of Manufacturing a Multiple Magnetic Recording |
| 3,117,367 | Jan. 14, 1964 | S. Duinker et al | Method of Manufacturing a Magnetic Head Having a Glass Spacer |
| 3,187,411 | June 8, 1965 | S. Duinker et al | Method of Manufacturing Pole-Piece Units for Magnetic Heads |
| 3,192,608 | July 6, 1965 | H. Rinia et al | Multiple Ferrite Heads with Workable Metal Screens |



500004

BEST COPY AVAILABLE

DEFENDANTS' EXHIBIT NN

GROUP XIII PATENTS

| PATENT NO. | ISSUE DATE | INVENTOR | TITLE |
|---|---|---|---|
| 3,224,073 | Dec. 21, 1965 | M. Peloschek | Method of Making Multi-Track Magnetic Heads |
| 3,228,092 | Jan. 11, 1966 | J. Van Langen et al | Magnetic Heads with Bonding Gap Spacers |
| 3,229,044 | Jan. 11, 1966 | J. Kokke | Adjustment of Magnetic Heads |
| 3,233,308 | Feb. 8, 1966 | S. Duinker et al | Method of Manufacturing Magnetic Heads Having Very Short Gap Lengths |
| 3,237,280 | March 1, 1966 | G. Manders | Method of Manufacturing Magnetic Heads |
| 3,302,268 | Feb. 7, 1967 | S. Duinker | Method of Manufacturing Magnetic Heads Using a Jig for Accurately Determining Gap Height |
| 3,330,033 | July 11, 1967 | G. Manders et al | Method of Manufacture of Supports for Magnetic Heads |
| 3,333,332 | Aug. 1, 1967 | M. Vrolijks et al | Method of Manufacturing Parts of Annular Magnetic Heads |
| 3,357,005 | Dec. 5, 1967 | J. Geurst et al | Multiple Magnetic Head Assembly |
| 3,369,292 | Feb. 20, 1968 | F. Manders | Method of Forming Glass Bonded Heads |
| 3,373,249 | Mar. 12, 1968 | G. Schager | Magnetic Erasing Head |
| 3,373,413 | Mar. 12, 1968 | J. Geurst et al | Multiple Magnetic Head Assembly |
| 3,375,575 | Apr. 2, 1968 | J. Visser et al | Heat and Pressure Glass Bonding of Spaced Magnetic Head Portions by Forming and Using Glass Over Flow Channels |
| 3,390,451 | July 2, 1968 | H. Peloschek | Multi-Track Magnetic Heads and Their Method of Manufacture |
| 3,395,450 | Aug. 6, 1968 | J. Koorneef et al | Method of Manufacturing Useful Gaps of Accurately the Same Length Throughout Their Width Between Two Circuit Parts of a Magnetic Head |



500005

DEFENDANTS' EXHIBIT NN

GROUP III PATENTS

| PATENT NO. | ISSUE DATE | INVENTOR | TITLE |
|---|---|---|---|
| 3,395,451 | Aug. 6, 1968 | H. Peloschek | Method of Manufacturing M Magnetic Heads Having Acc Defined Gap Heights |
| 3,402,463 | Sept. 24, 1968 | J. Bos et al | Method of Manufacturing Pa Piece Units for Magnetic |
| 3,435,155 | Mar. 25, 1969 | V. Van Der Voo | Pole Pieces for Magnetic with Accurately Determine Heights |



500006

566a

DEFENDANTS' EXHIBIT NN

December 8, 1970

170-2-3

Mr. George Winans, President
Tranetics Inc.
615 Citracado Parkway
Escondido, California 92025

Dear Mr. Winans:

Re: Magnetic Pole Piece
Patent License Agreement

U. S. Philips Corporation owns a number of patents which are regarded as basic in the art of glass bonding of pole pieces used in magnetic heads. We are now engaged in a licensing program in which we are offering non-exclusive licenses under such patents to companies like your own that manufacture such products. As you will note, if you do accept such a license, you will pay in consideration thereof to U. S. Philips a royalty based upon the selling price of the bonded pole pieces, and you will be able to pass on to your customers corresponding licenses under the patents that you elect pursuant to the provisions of the agreement.

I enclose herewith a copy of such an agreement for your consideration and request that you advise whether or not you are interested in accepting a license under any of the patents enumerated in Schedule A attached to the Agreement.

Your prompt reply to this letter is urged.

Very truly yours,

Jack Oisher

JO/lj

Enclosure

DEC 4 1970

500025

567a

DEFENDANTS' EXHIBIT NN

May 28, 1971

170-2-39

President, Magnetic Arts
Escondido - 1310 Industrial
California 92025

Dear Sir:

Re: Magnetic Pole Piece
Patent License Agreement

U.S. Philips Corporation owns a number of patents which are regarded as basic in the art of glass bonding of pole pieces used in magnetic heads. We are now engaged in a licensing program in which we are offering non-exclusive licenses under such patents to companies like your own that manufacture such products. As you will note, if you do accept such a license, you will pay in consideration thereof to U.S. Philips a royalty based upon the selling price of the bonded pole pieces, and you will be able to pass on to your customers corresponding licenses under the patents that you elect pursuant to the provisions of the agreement.

I enclose herewith a copy of such an agreement for your consideration and request that you advise whether or not you are interested in accepting a license under any of the patents enumerated in Schedule A attached to the Agreement.

Your prompt reply to this letter is urged.

Very truly yours,

Jack Oisher

JO/lj
bcc: Standard Pole Piece 12/4/70
Enclosure

500036

DEFENDANTS' EXHIBIT NN

May 28, 1971

170-2-39

Mr. Lee Dawson
Data Memory, Inc.
1255 Terra Bella
Mountain View, California 94040

Dear Mr. Dawson:

Enclosed herewith is a copy of our standard License agreement under which we are offering licenses in the pole piece bonding field. Please advise if you wish such a license.

Very truly yours,

Jack Oisher

JO/lj
cc: (blind) Standard Pole Piece 12/4/70
Enclosure

DEFENDANTS' EXHIBIT NN

May 28, 1971

170-2-39

Mr. R. L. Payne
Century Data Systems, Inc.
1270 N. Kraemer Blvd.
Anaheim, California 92806

Dear Mr. Payne:

In reply to your letter dated May 20, 1971, enclosed is a copy of our standard license agreement under which we are offering licenses in the field of bonding of magnetic pole pieces on the terms specified. If you wish such a license, please advise.

Very truly yours,

Jack Oisher

JO/lj
cc: (blind) Standard Pole Piece 12/4/70
Enclosure

570a

DEFENDANTS' EXHIBIT NN

170-2-39 October 7, 1971

Mr. Leo A. Brissette
President
Labtek Inc.
P. O. Box 103
Middleton, Mass. 01949

Re: Magnetic Head Pole Piece
Patent License Agreement

Dear Mr. Brissette:

U. S. Philips Corporation owns a number of patents which are regarded as basic in the art of glass bonding of pole pieces used in magnetic heads. We are engaged in a licensing program in which we are offering non-exclusive licenses under such patents to companies like your own.

I enclose herewith a copy of such an agreement for your consideration and request that you advise whether or not you are interested in accepting a license under any of the patents enumerated in Schedule A attached to the agreement.

Very truly yours,

Jack Oisher

JO/svl
Enclosure
Standard pole piece 12/4/70

500041

DEFENDANTS' EXHIBIT NN

170-2-39 October 7, 1971

Bell and Howell
Electronics & Instruments Group
360 Sierra Madre Villa
Pasadena, California 91109

Re: Magnetic Head Pole Piece
Patent License Agreement

Dear Sirs:

U. S. Philips Corporation owns a number of patents which are regarded as basic in the art of glass bonding of pole pieces used in magnetic heads. We are engaged in a licensing program in which we are offering non-exclusive licenses under such patents to companies like your own.

I enclose herewith a copy of such an agreement for your consideration and request that you advise whether or not you are interested in accepting a license under any of the patents enumerated in Schedule A attached to the agreement.

Very truly yours,

Jack Oisher

JO/svl
Enclosure
bcc: Standard pole piece 12/4/70

572a

DEFENDANTS' EXHIBIT NN

December 16, 1971

170-2-39

President
Ampex Corporation
Redwood City
California

Re: Magnetic Head Pole Piece
Patent License Agreement

Dear Sir:

U. S. Philips Corporation owns a number of patents which are regarded as basic in the art of glass bonding of pole pieces used in magnetic heads. We are engaged in a licensing program in which we are offering non-exclusive licenses under such patents to companies like your own.

I enclose herewith a copy of such an agreement for your consideration and request that you advise whether or not you are interested in accepting a license under any of the patents enumerated in Schedule A attached to the agreement.

Very truly yours,

Jack Oisher

JO/svl
Enclosure Standard Pole Piece Agr.

OCT 29 1971

503047

573a

DEFENDANTS' EXHIBIT NN

170-2-39

December 16, 1971

President
Ferronics Incorporated
Fairport, New York

Re: Magnetic Head Pole Piece
Patent License Agreement

Dear Sir:

U. S. Philips Corporation owns a number of patents which are regarded as basic in the art of glass bonding of pole pieces used in magnetic heads. We are engaged in a licensing program in which we are offering non-exclusive licenses under such patents to companies like your own.

I enclose herewith a copy of such an agreement for your consideration and request that you advise whether or not you are interested in accepting a license under any of the patents enumerated in Schedule A attached to the agreement.

Very truly yours,

Jack Oisher

JO/svl
Enclosure

OCT 29 1971

500048

574a

DEFENDANTS' EXHIBIT NN

170-2-39

December 16, 1971

Mr. Charles B. Pear
Staff Scientist
Potter Instrument Company, Inc.
East Bethpage Road
Plainview, New York 11803

Dear Mr. Pear:

Thank you for your letter dated December 1, 1971. As you may know, U.S. Philips owns a number of patents which are regarded as basic in the art of glass bonding of pole pieces used in magnetic heads. We are now engaged in a licensing program in which we offer non-exclusive licenses under such patents.

I enclose herewith a copy of such an agreement for your consideration and request that you advise whether or not you are interested in accepting a license under any of the patents enumerated in Schedule A attached to the agreement.

Very truly yours,

Jack Oisher

JO/svs
Enc. Standard Pole Piece

OCT 29 1971

500049

.575a

DEFENDANTS' EXHIBIT NN

170-2-39 December 16, 1971

President
3M Company
Minicomputer Division
Thousand Oaks, California

Re: Magnetic Head Pole Piece
Patent License Agreement

Dear Sir:

U. S. Philips Corporation owns a number of patents which are regarded as basic in the art of glass bonding of pole pieces used in magnetic heads. We are engaged in a licensing program in which we are offering non-exclusive licenses under such patents to companies like your own.

I enclose herewith a copy of such an agreement for your consideration and request that you advise whether or not you are interested in accepting a license under any of the patents enumerated in Schedule A attached to the agreement.

Very truly yours,

Jack Oisher

JO/svl
Enclosure
bcc: Standard pole piece 10/29/71

OCT 29 1971

500050

576a

DEFENDANTS' EXHIBIT NN

170-2-39 March 30, 1973

Mr. John B. Sowell
Sperry-Univac
P.O. Box 500
Blue Bell, Pennsylvania 19422

Dear Mr. Sowell:

In reply to your recent telephone call, I enclose, herewith, a copy of our standard Pole Piece License Agreement which offers licenses under the three patents you mentioned, numbers 3024318, 3246383, and 3376397. I also enclose copies of those patents plus copies of two other patents from among those listed which you may also find of interest, to wit, numbers 3435155 and 3531859.

For completeness sake, we now have pending against National Micronetics a suit for patent infringement of Patent Nos. 3024318, 3246383, and 3145453, of which I also include a copy of the latter.

If you have any questions, please donnot hesitate to write or call.

Very truly yours,

U. S. PHILIPS CORPORATION

Jack Oisher
Patent Department

JO/as
encl.

500086

DEFENDANTS' EXHIBIT NN

March 19, 1970

170-2-39

Mr. George A. Wenzel
Magnetic Head Corporation
95 Market Blvd.
Hauppauge, New York 11787

Dear Mr. Wenzel:

Re: Magnetic Head Patent License

Our Company owns a number of patents covering various forms of magnetic heads and processes of manufacture including glass-bonded ferrite heads. Recently we have made available to the industry non-exclusive licenses under one or more of our patents, at reasonable rates.

If your company is interested in acquiring such a license, please advise and we will forward you a copy of our standard agreement for your consideration.

Very truly yours,

Jack Oisher

:cjr

ADMISSIONS.

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

| | |
|---|---|
| U. S. PHILIPS CORP., Plaintiff, v. NATIONAL MICRONETICS INC., ET AL., Defendants, v. NORTH AMERICAN PHILIPS CORPORATION, and N. V. PHILIPS GLOEILAMPENFABRIEKEN, Counter-Defendants. | CIVIL ACTION NO. 71 CIV 921 (RO) |

RESPONSE BY U.S. PHILIPS CORPORATION TO DEFENDANTS' REQUESTS FOR ADMISSION OF DECEMBER, 1974

None of the following responses is to be deemed an admission as to the relevance, materiality or admissibility in evidence thereof, and plaintiff U.S. Philips Corporation reserves all objections to reception of any such admissions in evidence.

Responding to defendants' requests for admission of December 1974 (served on December 16, 1974) plaintiff U.S. Philips Corporation notes as follows:

REQUEST 11

Prior to the priority date for the 3,248,383 patent in suit, two materials have been bonded together with glass used as a solder.

Resp. 11. Not so far as is known to plaintiff.

REQUEST 12

Prior to the priority date of 3,024,318 patent in suit, two ferrite materials in a magnetic recording core have been bonded together by a glass material, the glass serving both as the sole gap spacing material and to bond the two facing ferrite members together.

ADMISSIONS.

REQUESTS 59-85

59. No license agreement covering any patent in suit is now in force between plaintiff and Magnetic Head Corporation, nor was there ever such an agreement.

60. The document marked by plaintiff with Bates Nos. 500002-06 is a true copy of a letter from Mr. Oisher to Burroughs Corporation dated June 26, 1970.

61. No license agreement covering any patent in suit is now in force between plaintiff and Burroughs Corporation nor was there ever such an agreement.

62. The document marked by plaintiff with Bates No. 500025 is a true copy of a letter from Mr. Oisher to Tranetics Inc., dated December 8, 1970.

63. No license agreement covering any patent in suit is now in force between plaintiff and Tranetics Inc., nor was there ever such an agreement.

64. The document marked by plaintiff with Bates No. 500026 is a true copy of a letter from Mr. Oisher to Micronetics, Inc., dated December 8, 1970.

65. No license agreement covering any patent in suit is now in force between plaintiff and Micronetics, Inc., nor was there ever such an agreement.

ADMISSIONS

66. The document marked by plaintiff with Bates No. 500036 is a true copy of a letter from Mr. Oisher to Magnetic Arts dated May 28, 1971.

67. No license agreement covering any patent in suit is now in force between plaintiff and Magnetic Arts, nor was there ever such an agreement.

68. The document marked by plaintiff with Bates No. 50037 is a true copy of a letter from Mr. Oisher to Data Memory, Inc., dated May 28, 1971.

69. No license agreement covering any patent in suit is now in force between plaintiff and Data Memory, Inc., nor was there ever such an agreement.

70. The document marked by plaintiff with Bates No. 500038 is a true copy of a letter from Mr. Oisher to Century Data Systems, Inc., dated May 28, 1971.

71. No license agreement covering any patent in suit is now in force between plaintiff and Century Data Systems, Inc., nor was there ever such an agreement.

72. The document marked by plaintiff with Bates No. 500041 is a true copy of a letter from Mr. Oisher to Labtek, Inc., dated October 7, 1971.

ADMISSIONS

73. No license agreement covering any patent in suit is now in force between plaintiff and Labtek, Inc., nor was there ever such an agreement.

74. The document marked by plaintiff with Bates No. 500042 is a true copy of a letter from Mr. Oisher to Bell and Howell dated October 7, 1971.

75. No license agreement covering any patent in suit is now in force between plaintiff and Bell and Howell, nor was there ever such an agreement.

76. The document marked by plaintiff with Bates No. 500047 is a true copy of a letter from Mr. Oisher to Ampex Corporation dated December 16, 1971.

77. No license agreement covering any patent in suit is now in force between plaintiff and Ampex Corporation, nor was there ever such an agreement.

78. The document marked by plaintiff with Bates No. 500048 is a true copy of a letter from Mr. Oisher to Ferronics Inc., dated December 16, 1971.

79. No license agreement covering any patent in suit is now in force between plaintiff and Ferronics Inc., nor was there ever such an agreement.

ADMISSIONS

80. The document marked by plaintiff with Bates No. 500049 is a true copy of a letter from Mr. Oisher to Potter Instrument Co., Inc., dated December 16, 1971.

81. No license agreement covering any patent in suit is now in force between plaintiff and Potter Instrument Co., Inc., nor was there ever such an agreement.

82. The document marked by plaintiff with Bates No. 500050 is a true copy of a letter from Mr. Oisher to 3M Company, dated December 16, 1971.

83. No license agreement covering any patent in suit is now in force between plaintiff and 3M Company, nor was there ever such an agreement.

84. The document marked by plaintiff with Bates No. 500056 is a true copy of a letter from Mr. Oisher to Sperry-Univac dated March 30, 1973.

85. No license agreement covering any patent in suit is now in force between plaintiff and Sperry-Univac, nor was there ever such an agreement.

Resp. 59-85. Admitted.

**TRANSLATION** DEFENDANTS' EXHIBIT U1E

from: Netherlands WB:daf

REPORT CONTACT MEETING NAT. LAB - KERAMISCH LAB.

on May 5, 1961

Present: Messrs. Haaijman, Jouwersma (part of the time), Louwerse, de Rooy, Stuyts, Veenemans, Wijnen.

I. Magnetic Recorder Heads

1. Sedimentation

The quantity of enamel which is applied is not yet sufficiently reproducible. Wijnen is to work further on this

The gaps are still of poor quality, particularly with respect to air bubbles. The experiments are to be continued by Vrolijks with preglazing at higher temperatures in order to see whether in this way it is possible to eliminate the air bubbles.

2. Enamel foil with organic binder

Operation with these foils is particularly pleasant. The quality of gap is still inadequate (air bubbles). Further work is to be done on this also by Wijnen/Vrolijks, if possible with higher glass concentrations, with preglazing on one of the surfaces with higher temperatures and with slow burning-out of the binder at low temperatures.

Wijnen is to examine whether a foil of glass can be made on an organic support.

3. The application of $SiO_2$ by vapor treatment for gaps is to be examined by Wijnen, for which he is to get in touch with Jochems and van Alphen.

4. Formation of glass fleeces with the aid of

**TRANSLATION**
from:

DEFENDANTS' EXHIBIT U1E

organic compounds of silicon, titanium, boron, etc. is to be examined by Wijnen together with Jouwersma.

5. The examination with the monolayers is to be continued since this may be of importance for given gap techniques.

II. Pasting of Harwell frame

It was decided that Louwerse together with Jouwersma should work out a proposal for a development contract with Harwell. The work in this contract is to be based on the translation of the study of Jouwersma for large tiles.

It is desired to take up this development contract at the budget meeting on June 19th next.

It was furthermore determined that it is desirable to obtain further insight into pasting methods with inorganic materials such as glass, ferrite, etc. Jouwersma is to examine this also.

III. Dense Ferrites

This point was postponed to the following meeting which is to be held on Tuesday, May 30th next at 9:00 a.m. at the office of Dr. Veenemans. Dr. de Jonge and v.d. Giessen (Nat. Lab) are also to be invited to this meeting.

Icoma Ker. Lab.
A.J. de Rooy

May 8, 1961/jr
copy to Messrs:

present +
Duinker
v.d. Giessen
de Jonge, Visser, Vrolijks

**TRANSLATION** DEFENDANTS' EXHIBIT U2E

from: Netherlands WB:daf MC:MJ

PARTIAL REPORT NAT. LAB. - KER. LAB. CONTACT MEETING

on May 30, 1961

Present: Messrs. Duinker, v.d. Giessen, Haayman, de Jonge, de Rooy, Troelstra, Veenemans, Vrolijks (part of the time), Wijnen, Stagts.

Gap techniquesmagnetic recorder heads

1) Sedimentation: in particular for the longer gaps (about 5 μ and larger) it looks as though the gap remains too porous. Vrolijks had the trouble that a part of the enamel fell off from the block. Glazing at lower temperature and presintering in vacuum is to be tried out at the Ker. Lab. in order, in this way, to obtain a flatter layer without gas bubbles.

It was decided to direct the experiments with the sedimentation method in particular at gaps of about 2 μ. For this purpose a number of blocks are to be covered with a thinner layer by Nat. Lab. for cement tests by the Ker. Lab.

2) Enamel foil with organic binder

The tests with this are to be continued at the Ker. Lab. Up to now the gaps which are made with foil still contain a large number of "bubbles" or pores.

3) Vapor application of SiO

It is possible herewith to apply layers up to 2 μ. Duinker is carrying out tests in order to determine whether these layers can be sintered "sec" or with glass monolayers to each other.

LAWYERS' & MERCHANTS' TRANSLATION BUREAU
Carl V. Bertsche (1908-1966) (Translating Service Bureau) Est. 1908 Wm. Bertsche, J.D., Ch. E., A.C.S.
PHONE (212) 344-2930-1 11 BROADWAY, NEW YORK, N. Y. 10004

**TRANSLATION**

from: DEFENDANTS' EXHIBIT U2E

4) Formation of glass fleeces with the use of organic compounds of silicon etc. This is too complicated for a simple test; for this reason this point for the time being is for memorandum only.

5) Monolayers

The gaps obtained with this method are particularly thin. For this reason the experiments are being continued at Nat. Lab. in combination with item 3.

6) Thin organic adhesive layer with layer of powder applied thereon.

The purpose is to make the powder particles adhere good and firm, whereafter it is possible to work further in the same manner as upon sedimentation. A few tests are to be carried out at Nat. Lab.

The report on dense ferrites is still to be given.

The following meeting will be held on Tuesday July 4th next at the office of Dr. Haaijman (9-10 o'clock dense ferrites, 10-11 o'clock magnetic recorder heads).

June 13, 1961/jr

Icoma Ker. Lab.
M. Vrolijks

Copies to Messrs:

present +

Visser

**TRANSLATION** DEFENDANTS' EXHIBIT U3E

from: Netherlands WB:daf NS-bK

REPORT CONTACT MEETING NAT. LAB - GLAS. LAB. - KER. LAB.

Concerning: Gap Techniques for magnetic recorder heads

held on August 29, 1861

Present: Messrs. Duinker, Haaijman, Padmos, de Rooy, Stuyts, Troelstra, Veenamans, Vrolijks, Wijnen.

1) Bubbles in glass gaps

Although a large number of tests have already been carried out, it is not clear what the cause of the gas bubbles is. A reduction in the quantity and size of the bubbles has been obtained at the Ker. Lab. by:

a) lower bonding temperature (about 720°C instead of 780°C)

b) starting from glass fibers which have been pressed out

c) starting from a glass plate of about 80 µ which is melted on the ferrite surface and heated at 900°C in a slight vacuum (1 cm Hg) for a few hours. Thereupon the layer of glass is ground down and polished to a thickness of about 10 µ whereupon the other profile is bonded thereon at 750°C. This gap was free of bubbles.

The use of methylated glass fleeces gave practically no improvement (extensive dispersion in the results).

In the Duinker group a number of cross-wise tests have been carried out with glass which is blown out at different times into fleeces and with ferrite from different suppliers and dimensions. From these tests no clear cause for

the occurrence of bubbles can be as yet concluded.

For the future the following tests were discussed:

A 1) after-melting in vacuum of batch glass. This is to be done at the Nat Lab.

A 2) thermal pretreatment of the ferrite, whereby better wetting of the ferrite by the glass is possible.

A 3) lowering of surface tension of the glass by addition of $B_2O_3$ or $V_2O_5$.

A 4) heating of the glass fleeces to about 500° in vacuum

A 5) the Glas. lab. has supplied fleeces and fibers of antimony refined glass. This is a better refining agent than the NaCl used up to now. Ker. Lab. will make gaps with it.

2) Enamel gaps

According to Duinker, enamel gaps greater than or equal to about 5 μ are not suitable for professional use with high tape speeds. In this connection it was observed, to be sure, that the enamel used up to the present time is not adapted to the coefficient of expansion so that in particular the longer gaps were frequently torn.

Vrolijks is to inquire of Mr. La Grouw as to a suitable enamel.

At low tape speeds, all heads were previously tested by Duniker, the reduction in quality being slight after 1000 hours.

from: DEFENDANTS' EXHIBIT U3E

3) Other gap materials

In a brief discussion there were taken up what other gap materials are possible and why they do not enter into consideration for the heads now under development

1) metal gaps: a) adherence is not always good

b) give probably poorer high frequency properties which are important in particular for professional heads.

c) life insufficient at high tape speeds.

2) glass-metal-glass gaps:

a) no attractive tight gaps, difficult to polish

b) c) same as with metal gaps.

For concrete agreements see attached report.

....continued on page 2

**TRANSLATION** DEFENDANTS' EXHIBIT U4E

from: Netherlands WB:daf

REPORT CONTACT MEETING NAT LAB. - KER. LAB. - GLAS. LAB. Re: gap techniques in ferrites for magnetic recorder heads, on October 3, 1961.

Present. Messrs. Duinker, v.d. Giessen, de Jonge, Padmos, de Rooy, Stuyta, Troelstra, Vrolijks, Wijnen.

1) Bubbles in glass gaps

1.1 Vacuum-melted glass

This was carried out by Rome (Meerkamp van Embden Group). Fibers and fleece were made from this by the Glas. Lab. Gaps were made herewith by the Ker. Lab.

Result

a) There was no clear improvement noticeable over "fleece gaps" from "normal" glass of the same composition.

b) In the case of the fiber gaps no clear improvement could be noted as compared with the finest normal fiber gaps. The average result of several bondings was to be sure better than the average of the fiber gaps.

1.2 Thermal pretreatment of the ferrite

Only a few tests have been carried out on this at the Ker. Lab. with glass fibers as gap material, no further improvement being obtained. With enamel as gap material much better wetting is obtained at the Nat. Lab.

The tests with glass fleece on preheated profiles are being carried out in the Duinker Group.

1.3 Decrease of surface tension in the glass

Glas. Lab. is busy with this. Contact angles can be

determined on samples.

1.4 Heating glass fleece in vacuum

At 500°C the glass fleece became so bent and bumpy that no gaps could be made any longer therewith. Furthermore it was believed that this test is actually only carried out well if the glass fleece after this heating no longer comes into contact with the (moist) outer air. In the de Jonge group apparatus is available in which the following test is to be carried out: 2 ferrite profiled parts with glass fleece between, are heated in vacuum to 400°C whereupon dry CO1-free air is admitted and the thread is bonded normally at about 730°C. A small measuring ring of the same ferrite is fired at the same time in order to determine whether the ferrite is not reduced ( $\mu$ and s measurement). Boter and Vrolijks are to carry out this test together.

2) Enamel gaps

With threads of enamel + organic binder very good gaps are reached.

An enamel with matched coefficient of expansion (EA 1037/06) has been delivered to Boter.

3) Test for resistance to wear

For the further development of the production of wear-resistant ferrites a rapid, reliable wear test is necessary.

From various sources it has been shown that the usefulness of results obtained in accelerated wear tests is particularly doubtful.

**TRANSLATION**

from: DEFENDANTS' EXHIBIT U4E

In order to arrive at a probing of existing possibilities it was decided that Duinker, de Jonge, and Peloschek should discuss this problem in order to arrive at a number of test methods which may possibly be employed. These methods should then be examined somewhere (T.N.O.?) as to the possibility of using them.

The next meeting is to be held on Friday, November 17th next at 9:00 a.m. at the office of Dr. Haaijman.

This does away with the originally scheduled date of November 7th next.

Agenda:

1) Bubbles in glass gaps

Course of investigation

2) Enamel gaps

Discussion of possible new results with the enamel matched in coefficient of expansion.

3) Test for resistance to wear

Discussion of result "in committee".

4) Examination of raw materials in connection with the preparation of dense ferrites.

S/Signature
Icoma Ker. Lab.
M. Vrolijks

October 31, 1961

Copy to Messrs.
present +
Haaijman
Veenemans

**TRANSLATION** DEFENDANTS' EXHIBIT U5E

*from:* Netherlands WB:daf

REPORT OF CONTACT MEETING NAT. LAB - GLAS. LAB - KER. LAB.

(November 17, 1961)

Subject: Gap techniques for magnetic recorder heads

Present: Messrs. Boter, Haayman, Padmos, de Rooy, Stuyts, Troelstra, Veenemans , Vrolijks, Wijnens.

1) Gaps for professional heads

a) For narrow cement surfaces ( less than or equal to about 1 mm), glass fibers can be pressed out into reasonably low-bubble gaps of 6-7 µ. Ker. Lab. is to carry out tests on the use of metal spacers (CuBe) instead of mica spacers.

b) A first test with the heating in vacuum of composite thread (ferrite + glass fleece) has given a bubble-free gap. The reproducibility is being investigated.

This method is not being examined primarily as possible method of production but in order to localize the cause of the bubbles.

c) In the case of wide cement surfaces the glass fiber method cannot be used. The pressures necessary in this connection bend the ferrite profile to the extent of microns so that the required accuracy in measurement of the gap cannot be obtained.

The following possibilities are to be investigated:

1) reduce cement surface by other design (apply stiffening later before cuts). Then one can work with fibers (Ker. Lab.).

2) replace the glass fibers by fibers of "enamel-like

glasses" (Ker. Lab.).

3) use of enamels to be applied by the thread technique (threads of enamel powder with organic binder) (Nat. Lab. + Ker. Lab.).

For this the enamel powder of matched coefficient of expansion should be used.

2) Glass gaps in general

Results of the different additions to the glass and pretreatment of the ferrite:

a) Addition of antimony as refining agent instead of NaCl.

Upon the use of fleeces and fibers there could not be noted any clear improvement with respect to gaps made with corresponding techniques in NaCl-refined glass.

b) The glass with $V_2O_5$ addition also did not show any improvement (only a few cementings carried out as yet).

c) Thermal pretreatment and ultrasonic cleaning of the ferrite profiles also gave no improvement.

3) Wear-resistant gap materials

a) Of the 4 heads delivered to the Ela (not yet matched enamel), 3 were disappointing upon the working there. Heads with matched enamel should be delivered rapidly so that results are known upon the next discussion.

b) The Glas. Lab. has no experience on the behavior of the wear resistance of glasses and various enamels.

c) Peloschek is to compile, for the next meeting,

**TRANSLATION**

*from:* DEFENDANTS' EXHIBIT U5E

a summary of the gap materials and techniques examined at different places and the experience obtained thereby.

On basis also of this the future development can then be oriented. It will then be decided whether in addition to (or possibly instead of) glass or enamel other gap materials should also be examined.

4. Measurement of wear resistance

Stuyts advised that in his group a secondary school student has started with the investigation of the sandblast method as method of measurement for the wear resistance of the ferrite.

The next meeting will be held on Thursday, December 21st next at 2:00 p.m. at the office of Dr. Veenemans.

From 2:00 p.m. until 3:30 p.m. gap techniques and materials will then be discussed, and after 3:30 p.m. raw materials.

S/Signature

Icoma Ker. Lab.
M. Vrolijks

November 24, 1961/JMR

copy to Messrs.

Present +
Duinker

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Darby & Darby 3/2/76

Attorney for